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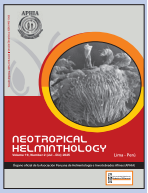

REVIEW ARTICLE / ARTÍCULO DE REVISIÓN

MAIN SITES OF HELMINTH INFECTION REPORTED IN MARSUPIALS OF THE GENUS *DIDELPHIS* AND THE PERSPECTIVE OF THE PARASITE-HOST RELATIONSHIP

PRINCIPALES SITIOS DE INFECCIÓN POR HELMINTOS REPORTADOS EN MARSUPIALES DEL GÉNERO *DIDELPHIS* Y LA PERSPECTIVA DE LA RELACIÓN PARÁSITO-HUESPED

PRINCIPAIS SÍTIOS DE INFECÇÃO POR HELMINTOS RELATADOS EM MARSUPIAIS DO GÊNERO *DIDELPHIS* E A PERSPECTIVA DA RELAÇÃO PARASITA-HOSPEDEIRO

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ABSTRACT

Parasitism in *Didelphis* can express different physiological impacts resulting from the parasite load, as well as the affected organ. It is therefore pertinent to identify the sites and locations of infection to understand the possible effects on the host. The present work is a systematic literature review study on articles that described the presence of parasites and their respective sites of infection. Of the 114 studies retrieved in the literature, 54 were eligible to be included in this review. Based on the studies analyzed, the sites identified were organs and/or regions that include the: heart, mesenteric arteries,

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brain/cerebrum, oral mucosa, esophagus, stomach, small/large intestine, liver, gallbladder, lungs, bronchi, and bronchioles, in addition to other structures and regions. In terms of impact on the host, the analyzed infection sites suggest significant functional impairment, especially in digestive and respiratory structures. This may result in changes to behavioral, locomotion, reproductive capacity, and to losses in survival rates for the animals, in addition to modifying their interaction with the ecosystem and other species, including humans. The findings also reflect the ecological importance of opossums as intermediate and/or definitive hosts for a wide variety of helminths, many of which are of health concern due to their zoonotic potential.

Keywords: *Didelphis* – Lesions – Opossum – Organ – Region – Site of infection

RESUMO

O parasitismo em *Didelphis* pode expressar diferentes impactos fisiológicos resultantes da carga parasitária, bem como do órgão afetado. Portanto, é pertinente identificar os sítios e localizações da infecção para entender os possíveis efeitos no hospedeiro. O presente trabalho é um estudo de revisão sistemática da literatura sobre artigos que descreveram a presença de parasitas e seus respectivos sítios de infecção. Dos 114 estudos recuperados na literatura, 54 foram elegíveis para inclusão nesta revisão. Com base nos estudos analisados, os sítios identificados foram órgãos e/ou regiões que incluem: coração, artérias mesentéricas, cérebro/cérebro, mucosa oral, esôfago, estômago, intestino delgado/grosso, fígado, vesícula biliar, pulmões, brônquios e bronquíolos, além de outras estruturas e regiões. Em termos de impacto no hospedeiro, os sítios de infecção analisados sugerem comprometimento funcional significativo, especialmente em estruturas digestivas e respiratórias. Isso pode resultar em alterações no comportamento, na locomoção, na capacidade reprodutiva e em perdas nas taxas de sobrevivência dos animais, além de modificar sua interação com o ecossistema e outras espécies, incluindo humanos. Os resultados também refletem a importância ecológica dos gambás como hospedeiros intermediários e/ou definitivos para uma ampla variedade de helmintos, muitos dos quais representam uma preocupação para a saúde devido ao seu potencial zoonótico.

Palavras-chave: *Didelphis* – Gambá – Lesões – Local da infecção – Órgão – Região

RESUMEN

El parasitismo en *Didelphis* puede manifestar diferentes efectos fisiológicos dependiendo de la carga parasitaria y el órgano afectado. Por lo tanto, es importante identificar los sitios y las localizaciones de la infección para comprender los posibles efectos en el huésped. Este estudio es una revisión sistemática de la literatura de artículos que describen la presencia de parásitos y sus respectivos sitios de infección. De los 114 estudios recuperados, 54 fueron elegibles para su inclusión en esta revisión. Con base en los estudios analizados, los sitios identificados fueron órganos y/o regiones que incluyen: corazón, arterias mesentéricas, cerebro, mucosa oral, esófago, estómago, intestino delgado/grueso, hígado, vesícula biliar, pulmones, bronquios y bronquiolos, así como otras estructuras y regiones. En términos del impacto en el huésped, los sitios de infección analizados sugieren un deterioro funcional significativo, especialmente en las estructuras digestivas y respiratorias. Esto puede resultar en cambios en el comportamiento, la locomoción, la capacidad reproductiva y la disminución de las tasas de supervivencia, así como en la modificación de sus interacciones con el ecosistema y otras especies, incluyendo a los humanos. Los resultados también reflejan la importancia ecológica de las zarigüeyas como hospedadores intermediarios y/o definitivos de una amplia variedad de helmintos, muchos de los cuales representan un riesgo para la salud debido a su potencial zoonótico.

Palabras clave: *Didelphis* – Lesiones – Órgano – Región – Sitio de infección – Zarigüeya

INTRODUCTION

Opossums are marsupials belonging to the family Didelphidae, which comprises 95 of the more than 125 existing species. They have a predominant geographic distribution in the Americas, representing one of the oldest groups of marsupials, dating back to the Upper Cretaceous period, and probably originated in South America. The genus *Didelphis* Linnaeus, 1758 is distributed from southeastern Canada to southeastern Argentina (Jansen, 2002; Do Nascimento, 2008; Jiménez *et al*., 2024).

The "New World Marsupials", as they are known, comprise six species of *Didelphis*, among them *Didelphis virginiana* (Kerr, 1792), which occurs in North and South American countries. In South America, two groups are more common, the marsupialis group, or black-eared opossums, *Didelphis marsupialis* (Linnaeus, 1758) (Dm) and *Didelphis aurita* Wied-Neuwied 1826 (Da), and the albiventris, or white-eared opossums, *Didelphis albiventris* Lund, 1840 (Dal), *Didelphis pernigra* J.A. Allen, 1900, and *Didelphis imperfecta* Mondolfi & Pérez-Hernández, 1984 (Gardner 2008; Faria & De Melo 2017).

The diet of these animals is diverse and reflects their opportunistic omnivorous behavior, which involves feeding on a variety of fruits, insects, arthropods, small vertebrates, and even food scraps left by humans. In urban areas, they are often seen searching for food in garbage, while in wild environments, their diet includes snakes, amphibians, birds, and eggs, also contributing to the ecological control of populations of insects, venomous animals, and small mammals (Freitas *et al*., 2022; Ferreira *et al*., 2025).

Because the opossums' diet is quite diverse (opportunistic feeding behavior), they end up being exposed to numerous gastrointestinal parasites, including those with zoonotic potential, such as the genera *Ancylostoma* (Dubini,1843), *Toxocara* Stiles & Hassall, 1905, *Trichuris* Roederer, 1761, *Ascaris* Linnaeus, 1758, *Capillaria* Zeder, 1800, *Cruzia* Travassos, 1917, *Strongyloides* Grassi, 1879, *Turgida* Schulz, 1927, *Didelphostrongylus* Prestwood,1976, *Giardia* Künstler, 1882, and *Cryptosporidium* Tyzzer, 1907. This diversity also reflects the possible sites of infection and consequently, the possible physical-physiological impacts on the host (Bezerra-Santos *et al*., 2020; De Jesus, 2020).

Pathological changes can be associated with the parasitic load in the host, as well as the affected organ (either directly due to the presence of the parasite or indirectly due to active migration or release of toxins and excretions), which in the short or medium term can impact on the host's habits far beyond the spoliation of nutrients from the intestinal region (Antunes, 1987; De Jesus, 2020).

Due to the possible presence of different parasites with different characteristics and infection sites and the potential physiological and behavioral impairment of the host, facilitating its predation by other animals, or even accidents involving human beings, this study aims to systematically review the main infection sites. This review seeks to understand the possible impacts generated from the parasite-host relationship in *Didelphis*.

MATERIALS AND METHODS

Type of Study

This is a qualitative systematic review that focuses on describing helminths reported in opossums of the genus *Didelphis* in the time frame from 1948 to 2024. The recommendations of the PRISMA 2020 guidelines were adopted and adapted (Page *et al*., 2021) for the study design to ensure greater transparency of the methodology approached and results obtained.

Descriptors and Databases

The active search was performed by searching for articles in all languages in the Scientific Electronic Library Online (SciELO), National Library of Medicine (PubMed), and Virtual Health Library (VHL) platforms, adopting the combination of English descriptors registered in the VHL: Helminths (Helminthe) (ID: D006376) and *Didelphis* (ID: D016848). The English terms were combined using the Boolean operator AND that limits the results of a search to documents that contain all the specified descriptors, in order to optimize the search.

Inclusion and Exclusion Criteria

Primary studies reporting identified helminths recovered from necropsies of *Didelphis* specimens published between 1948 and 2024 were included. Studies outside the study theme, duplicates, studies that were unable to identify the family or group of the helminth reported, as well as review articles, notes, comments, or with incomplete results were excluded.

Search Strategy

Data collection was carried out from March to May 2025, when the initial evaluation of the bibliographic material occurred by reading the titles and abstracts to select those

that met the objectives of the study, followed by a thorough reading and filing of the selected articles according to the inclusion and exclusion criteria mentioned above. Recorded in spreadsheets in the Excel 365 program to construct the figures of interest. Two independent reviewers reviewed all data (Fig. 1).

Summary of Results

The database search results were organized in a flowchart. After being reviewed by two independent researchers, the studies considered suitable for inclusion in the research were categorized according to the parasites reported in their respective infection sites. The following details were documented: year of publication, authors, country, host; parasites and infection site were recorded. In addition, illustrations were created quantifying and describing the infection sites and the respective findings of each author in order to allow the identification and perception of future study perspectives.

The final text was compiled by critically comparing the main results of each study and incorporating all relevant electronic articles for discussion. The information was organized according to the region reported, as well as the number of studies conducted.

Ethical Aspects

This article does not contain any animal experiments performed by any of the authors.

Active Search Flowchart (Fig. 1).

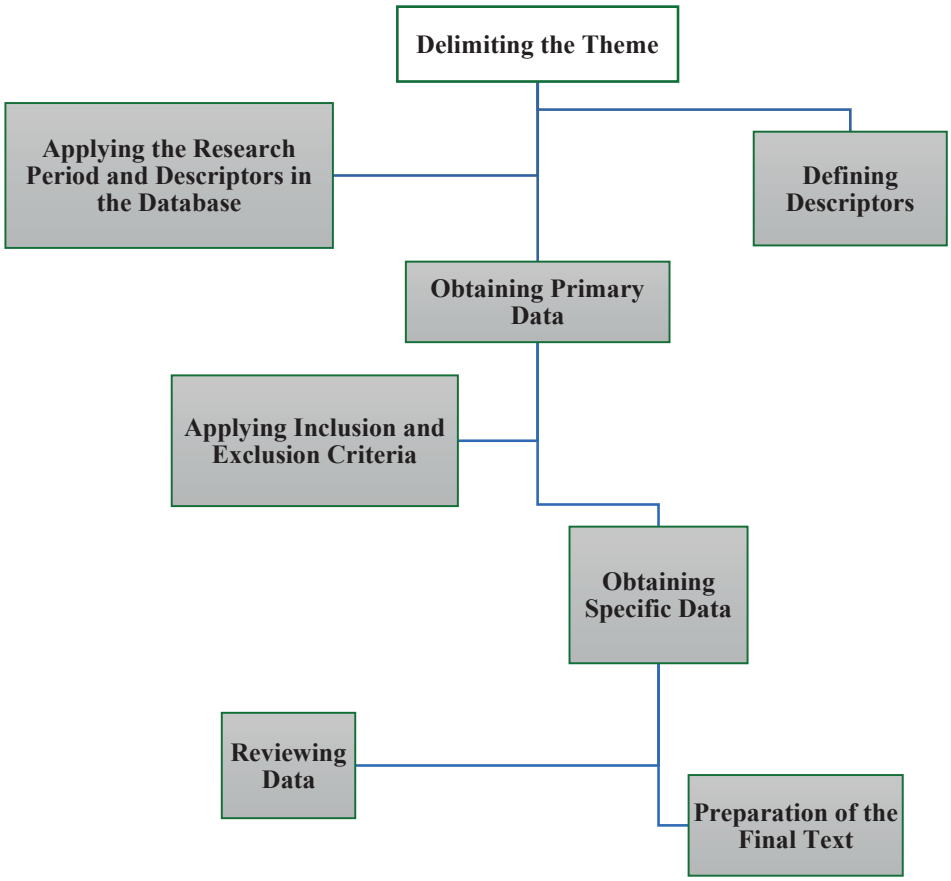


Figure 1. Presents the flowchart of the research and indicates the main steps that were taken.

RESULTS

The retrospective analysis of 76 years of research resulted in 114 articles found in the three databases within the stipulated time frame. Of these, 87 studies were found in PubMed, 26 in VHL and 1 in SciELO. With the application of the inclusion and exclusion criteria, 87 studies

were included primarily because they met the established criteria and after the exclusion of duplicates, 54 scientific texts comprised the present study, as shown in Fig. 2.

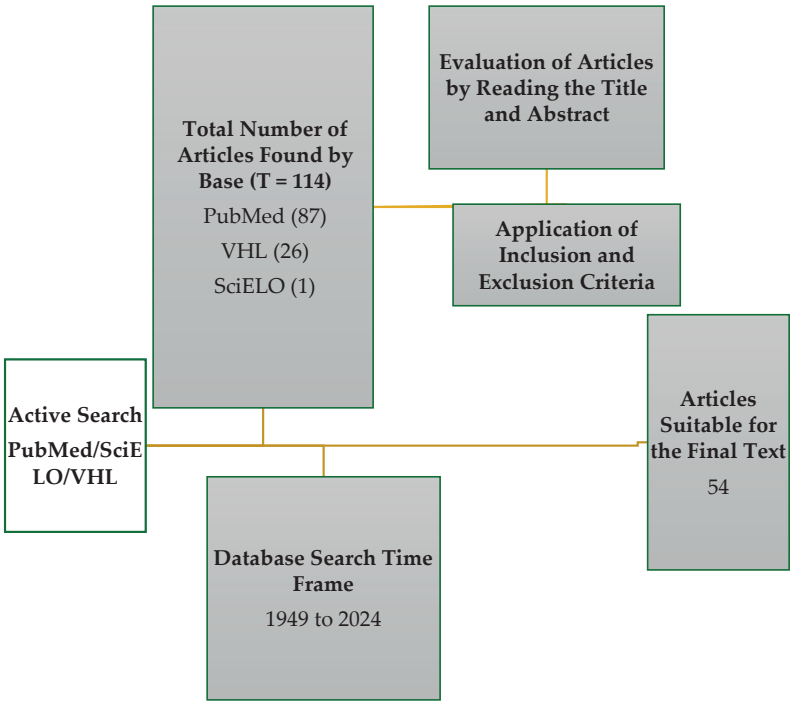


Figure 2. Flowchart for obtaining suitable articles from the databases: PubMed, VHL, and SciELO.

The results regarding the review on the occurrence of helminths in different hosts of the genus *Didelphis*, their respective infection sites, countries of registration, and author(s) are available in Table 1. It is worth mentioning that some studies carried out analyzed more than one host species, with this record being scored separately in the text.

Table 1. Suitable studies to compose the research according to: Year, authors, country, host, parasite and infection site.

N°	Author(s)/ Year (Ref No)	Country	Host	Site of Infection// Parasite
01	Crites (1956)	USA	Dv	**Large Intestine** *Cruzia* americana Maplestone, 1930
02	Sandars (1958)	USA	Dm	**Brain and Maxillary Sinus** *Achillurbainia recondite* Travassos, 1942 **Small-Large Intestine** *Rhopalias coronatus* Rudolphi, 1819 Stiles & Hassall,1898 **Gallbladder** *Metadelphis evandroi* Travassos, 1944
03	Babero (1960)	USA	Dv	**Esophagus** *Capillaria longicauda* Freitas & Lent, 1935 / *Gongylonema longispiculum* Schulz, 1927 / *Dipetalonema* sp. Diesing, 1861 **Lungs** *Dipetalonema* sp. **Heart** *Dirofilaria* sp. Railliet & Henry, 1911 *Gnathostoma didelphis* Chandler, 1932 **Stomach** *Gnathostoma* sp. Owen, 1837 **Intestine** *Trichuris minuta* Rudolphi, 1819 Chandler, 1930 / *Trichuris didelphis* Babero, 1960 **Small Intestine** *Mesocestoides variabilis* Mueller, 1928 / *Hamanniella tortuosa* Leidy, 1850
04	Stewart & Dean (1971)	USA	Dm	**Stomach** *Didelphonema longispiculata* Hill, 1939
05	Pence & Little (1972)	USA/ Costa Rica/ Colombia	Dm	**Buccal Mucosa** *Anatrichosoma buccalis* Pence & Little, 1972

06	Kinsella & Winegarner (1975)	USA	Dv	**Buccal Mucosa** *Anatrichosoma bucalis*
07	Nettles *et al*. (1975)	USA	Dm	**Lungs** *Capillaria aerophila* Creplin, 1839 Dujardin, 1845 **Estômago** *Physaloptera turgida* Schulz, 1927 **Cecum and Large Intestine** *Brachylaima virginianum* Dickerson, 1930 Krull, 1934 / *Cruzia americana*
08	Prestwood (1976)	USA	Dm	**Lungs** *Didelphostrongylus hayesi* Prestwood,1976
09	Prestwood *et al*. (1977)	USA	Dm	**Lungs** *Didelphostrongylus hayesi* / *Capillaria* sp.
10	Esslinger & Smith (1979)	USA	Dv	**Subcutaneous and Periesophageal Connective Tissues** *Dipetalonema* (*Acanthocheilonema*) *didelphis* Esslinger & Smith, 1979
11	Gray & Anderson (1982)	USA	Dv	**Stomach** *Turgida turgida* Schulz, 1927 Rudolphi, 1819
12	Bowman *et al*. (1983)	USA	Dv	**Stomach** *Lagochilascaris sprenti* Bowman, Smith & Little, 1983
13	Smith *et al*. (1983)	USA	Dv	**Stomach** *Lagochilascaris sprenti*
14	Ducan J. *et al*. (1989)	USA	Dv	**Lungs** *Didelphostrongylus hayesi*
15	Snyder *et al*. (1991)	USA	Dv	**Lungs** *Capillaria didelphis* Butterworth & Beverley-Burton, 1977 **Stomach** *Turgida turgida* **Large Intestine** *Cruzia americana*

16	Ellis *et al.* (1999)	USA	Dv	**Stomach** *Gnathostoma didelphis*/ *Physaloptera turgida* **Small Intestine** *Centrorhynchus spinosus* Kaiker, 1893 Van Cleave, 1924/ *Mesocestoides variabilis*/ *Longistriata didelphis* Travassos & Darriba, 1929 / *Oligacanthorhynchus tortuosa* Leidy, 1850 Schmidt, 1972 / *Viannaia hamata* Travassos,1914/ *Brachylaima virginiana* Dickerson, 1930/ *Didelphodiplostomum variabile* Chandler, 1932 Dubois, 1945/ *Rhopalias macracanthus* Chandler, 1932 **Large Intestine** *Cruzia americana*/ *Oligacanthorhynchus tortuosa*/ *Trichuris didelphis*
17	Silva & Costa (1999)	Brazil	Dal	**Esophagus** *Gongylonema* sp. Molin, 1857 **Stomach** *Turgida turgida* **Small Intestine** *Brachylaema migrans* Dujarin, 1845 / *Viannaia hamata*/ *Travassostrongylus orllofi* Travassos, 1935 **Large Intestine** *Rhopalias coronatus*/ *Aspidodera raillieti* Travassos, 1913 / *Cruzia tentaculata* Rudolpohi, 1819 / *Trichuris didelphis*/ *Capillaria* sp.
18	Cruz *et al*. (2000)	Argentina	Dal	**Small Intestine** *Duboisiella proloba* Baer, 1938
19	Cañeda-Guzmán *et al.* (2001)	Mexico	Dm	**Intestine** *Thaumasioscolex didelphidis* Cañeda-Guzmán, de Chambrier & Scholz, 2001
20	Matey *et al* (2001)	USA	Dv	**Stomach** *Turgida turgida*
21	Kim *et al*. (2002)	USA	Dv	**Brain** *Parastrongylus* (=*Angiostrongylus*) *costaricensis* Morera & Cespedes, 1971
22	Lamberski *et al*. (2002)	USA	Dv	**Lungs** *Didelphostrongylus hayesi*

23	Salgado-Maldonado & Cruz-Reyes (2002)	Mexico	Dv	**Small Intestine** *Porrorchis nickoli* Salgado-Maldonado & Cruz-Reyes, 2002
24	Campbell, *et al.* (2003)	Argentina	Dal	**Small Intestine** *Mathevotaenia argentinensis* Campbell, Gardner & Navone, 2003
25	Monet-Mendoza *et al.* (2005)	Mexico	Dv	**NOT DESCRIBED IN THE ARTICLE*** **Lungs** *Paragonimus mexicanus* Miyazaki & Ishii, 1968 / *Didelphostrongylus hayesi* **Stomach** *Didelphonema longispiculata*/ *Turgida turgida*/ *Gnathostoma turgidum* Stossich, 1902 **Liver** *Gnathostoma turgidum* **Intestine** *Oncicola luehei* Travassos, 1917 **Small Intestine** *Brachylaima virginiana*/ *Brachylaima* sp. Dujardin, 1843 / *Rhopalias coronatus*/ *Rhopalias macracanthus*/ *Mathevotaenia* sp. Akhumyan, 1946 / *Trichuris* sp./ *Viannaia* sp. Travassos, 1914 / *Viannaia didelphis* Travassos, 1914 / *Viannaia viannai* Travassos, 1914 **Large Intestine** *Oligacanthorhynchus tortuosa*/ *Cruzia* sp./ *Cruzia americana*/ *Cruzia tentaculata*/ *Didelphonema longispiculata* **Cecum** *Trichuris* sp./ *Didelphonema longispiculata*
26	Miller *et al*. (2006)	USA	Dv	**Mesenteric Arteries - Intestine** *Parastrongylus* (=*Angiostrongylus*) *costaricensis*
27	Chagas-Moutinho *et al*. (2007)	Colombia	Dm	**Large Intestine** *Aspidodera raillieti*

				Lungs *Didelphostrongylus hayesi*
28	Nichelason *et al*. (2008)	USA	Dv	**Stomach** *Turgida turgida* **Large Intestine** *Cruzia americana*
29	Adnet *et al*. (2009)	Colombia	Dm	**Large Intestine** *Cruzia tentaculata*
30	Díaz-Camacho *et al*. (2009)	Mexico	Dv	**Liver / Stomach** *Gnathostoma turgidum*
31	Nawa *et al*. (2009)	Mexico	Dv	**Lungs / Stomach / Small-Large Intestine** *Gnathostoma turgidum*
32	Díaz-Camacho *et al*. (2010)	Mexico	Dv	**Liver** *Gnathostoma turgidum*
33	Jiménez *et al.* (2011)	Guiana Francesa	Dm	**Stomach** *Spirura guianensis* Ortlepp, 1924 **Small Intestine** *Mathevotaenia bivittata* / *Travassostrongylus paraquintus*/ *Viannaia viannai* / *Oncicola campanulata* Diesing, 1851 **Large Intestine** *Aspidodera raillieti* / *Capillaria eberthi* Freitas & Lent, 1935/ *Trichuris reesali* Wo§fgang, 1951 **Cecum** *Aspidodera raillieti* / *Capillaria eberthi* / *Trichuris reesali*
34	Chagas-Moutinho *et al*. (2014)	Rio de Janeiro	Da	**Intestine / Cecum** *Aspidodera lanfredi* Chagas-Moutinho, Sant'Anna, Oliveira-Menezes & Souza, 2014
35	Torres-Montoya *et al*. (2014)	Mexico	Dv	**Liver / Stomach** *Gnathostoma turgidum*

				Dm* **Lungs** Capillariinae Railliet, 1915 **Gallbladder** *Amphimerus caudalitestis* Caballero, Grocott & Cerecero, 1952 / *Philandrophilus magnacirrus* Thatcher, 1970 **Stomach** *Gnathostoma turgidum* / *Turgida turgida* **Liver** *Gnathostoma turgidum* **Intestine** *Rhopalias coronatus* / *Rhopalias macracanthus* / *Thaumasioscolex didelphidis* / *Oncicola luehei* / *Viannaia viannai* **Cecum** *Cruzia tentaculata* / *Trichuris didelphis* **Dv*** **Lungs** *Didelphostrongylus hayesi* / Capillariinae **Gallbladder** *Amphimerus caudalitestis* **Stomach** *Gnathostoma turgidum* / *Gongylonema* sp. / *Turgida turgida* **Liver** *Gnathostoma turgidum* **Intestine** *Brachylaima didelphus* / *Rhopalias coronatus* / *Rhopalias macracanthus* / *Thaumasioscolex didelphidis* / *Oligacanthorhynchus microcephalus* Rudolphi, 1819 Schmidt, 1972 / *Porrorchis nickoli* / *Aspidodera raillieti* / Viannaia viannai **Cecum** *Cruzia tentaculata* / *Trichuris didelphis* **Dsp*** **Stomach** *Gnathostoma turgidum* / *Turgida turgida* **Liver** *Gnathostoma turgidum* **Intestine** *Rhopalias coronatus* / *Rhopalias macracanthus* **Cecum** *Cruzia tentaculata* / *Trichuris didelphis*
36	Acosta-Virgen *et al*. (2015)	Mexico	Dm/Dv/ Dsp	

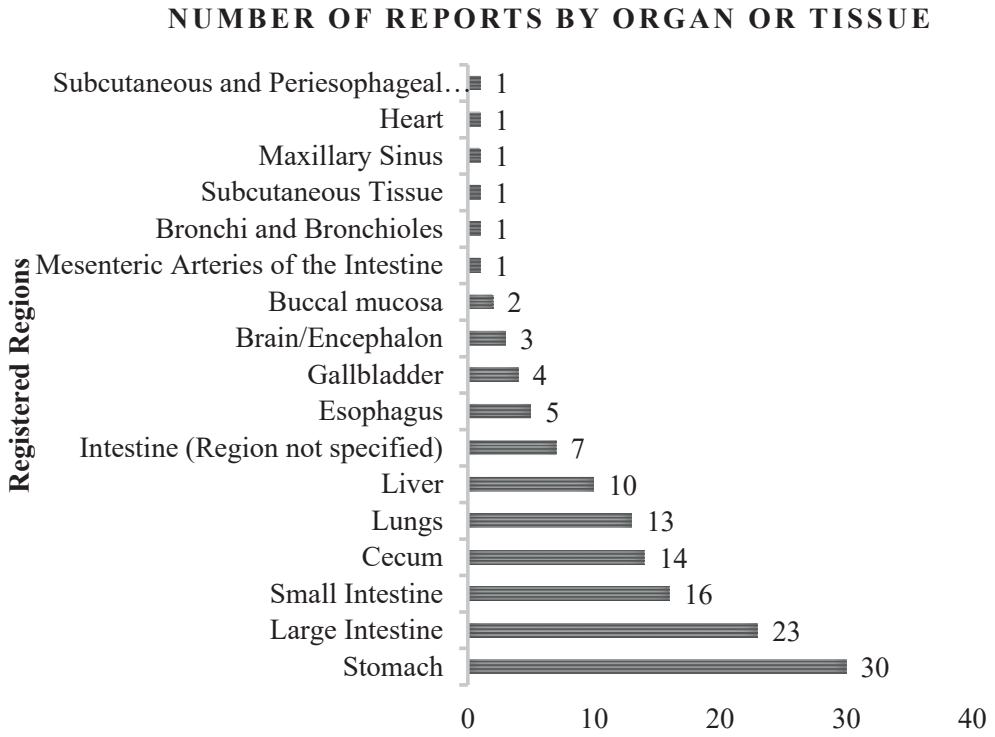
37	Costa-Neto *et al*. (2016)	Brazil	Dm	**Lungs** *Heterostrongylus heterostrongylus* Travassos, 1925
38	Lópes-Crespo *et al*. (2017)	Mexico	Dv	**Stomach** *Didelphostrongylus hayesi*
39	Zabott *et al*. (2017)	Brazil	Dal	**Stomach** *Turgida turgida* **Small Intestine** *Cruzia tentaculata* *Aspidodera* sp. Railliet & Henry, 1912 / *Trichuris* sp. **Large Intestine** *Hamanniella microcephala* Rudolphi, 1819 / *Rhopalias coronatus*
40	Torres-Montoya (2018)	Mexico	Dv	**Stomach/ Liver** *Gnathostoma turgidum*
41	Costa-Neto (2019)	Brazil	Da	**Bronchi/Bronchioles** *Heterostrongylus heterostrongylus* **Stomach** *Turgida turgida* **Small Intestine** *Travassostrongylus orloffi* / *Viannaia hamata* / *Globocephalus marsupialis* Teixeira de Freitas & Lent, 1936 / *Duboisiella proloba* / *Brachylaima advena* Dujardin, 1843 / *Rhopalias coronatus* / *Oligacanthorhynchus microcephalus* / Cestoda Unidentified **Large Intestine** *Aspidodera raillieti* / *Cruzia tentaculata* / *Trichuris minuta* / *Trichuris didelphis*
42	Li (2019)	USA	Dv	**Large Intestine** *Cruzia americana*
43	Cleveland *et al*. (2020)	Mexico	Dv	**Subcutaneous** *Dracunculus insignis* Leidy, 1856 Chandler, 1942
44	Gárcia-Varela *et al*. (2020)	Mexico	Dv	**Large Intestine** *Porrorchis nickoli*

				PRESUMPTION - NOT REPORTED **Lungs** *Heterostrongylus heterostrongylus* **Stomach** *Turgida turgida* **Small Intestine** *Mathevotaenia* sp. *Viannaia hamata* / *Viannaia* sp. / *Travassostrongylus orloffi* / *Rhopalias coronatus* / *Globocephalus marsupialis* **Large Intestine** *Cruzia tentaculata* / *Oligacanthorhynchus microcephalus* / *Trichuris minuta* / *Trichuris didelphis* **Cecum** *Trichuris minuta* / *Trichuris didelphis*
45	Cardoso *et al*. (2021)	Brazil	Da	
46	Ramírez-Cañas *et al.* (2021)	Mexico	Dv	**Small Intestine** *Viannaia angelae* Ramirez-Canas, Lopez-Caballero & Mata-Lopez, 2021
47	Cirino *et al*. (2022)	Brasil	Dal	**Stomach** *Turgida turgida* **Small Intestine** *Travassostrongylus orloffi* / *Viannaia hamata* / *Brachylaima advena*/ *Rhopalias coronatus* / *Hoineffia* sp. Diaw, 1976 / *Viannaia* sp. / Cestoda Unidentified **Large Intestine** *Aspidodera raillieti* / *Cruzia tentaculata* / *Trichuris didelphis* / *Trichuris minuta*
48	Freitas *et al*. (2022)	Brazil	Dm	**Large Intestine/Cecum** *Aspidodera raillieti* / *Cruzia tentaculata* / *Didelphonema longispiculata* / *Travassostrongylus orloffi* / *Trichuris minuta* / *Turgida turgida* / *Viannaia hamata* / *Oligacanthorhynchus microcephalus* / Cestoda Unidentified
49	Freitas *et al*. (2022)	Brazil	Dm	**Stomach** *Didelphonema longispiculata*
50	Souza *et al*. (2022)	Brazil	Da/Dal	**Large Intestine/Cecum*** *Cruzia tentaculata*

51	Varella *et al*. (2022)	Brazil	Da/Dal	**Large Intestine/Cecum*** *Aspidodera raillieti*
52	Vielmo *et al*. (2022)	Brazil	Dal	**Brain / Esophagus / Stomach / Large Intestine** *Angiostrongylus cantonensis* Chen, 1935
53	Jiménes *et al*. (2024)	Bolivia	Dm/Dal	**Dm*** **Stomach** *Turgida turgida* **Small Intestine** *Viannaia hamata* / *Viannaia simplicispicula* Navone, Suriano & Pujol, 1991/ *Viannaia skrjabini* Lent & Freitas, 1937 / *Viannaia viannai*/ *Oligacanthorhynchus microcephala* **Large Intestine/Cecum** *Aspidodera raillieti* **Dal*** **Stomach** *Turgida turgida* **Large Intestine/Cecum** *Aspidodera raillieti* / *Cruzia tentaculata*
54	Panti-May *et al*. (2024)	Mexico	Dv	**Esophagus/Stomach** *Turgida turgida* **Liver** *Platynosomum illiciens* Braun, 1901 **Small Intestine** *Brachylaima* sp. / *Mathevotaenia* sp. / *Viannaia* sp. / *Viannaia arriaguensis* Ramírez-Cañas, López-Caballero & Mata-López / *Travassostrongylus* sp. Orloff, 1933 **Intestine** *Oligacanthorhynchus microcephalus* **Cecum** *Cruzia americana*/ *Cruzi tentaculata*/ *Trichuris minuta*

*Studies that reported parasites in more than one species of *Didelphis* were recorded separately by host and their respective infection sites, except in cases where the parasite and infection site are the same.

Based on the studies analyzed, the sites where parasitic helminths were recovered are organs/regions that comprise the following systems: Cardiovascular (Heart and Mesenteric Arteries); Nervous (Brain/Cerebral); Digestive (Buccal Mucosa, Esophagus, Stomach, Small/Large Intestine/Liver and Gallbladder); Respiratory (Lungs, Bronchi and Bronchioles), in addition to other structures and regions (subcutaneous/connective tissue and Maxillary sinus). The number of sites reported per host is shown in Fig. 3.



*Studies that reported parasites in more than one *Didelphis* species were quantified separately by host.

Figure 3. Number of records per reported infection site in *Didelphis* species.

DISCUSSION

Gastrointestinal Tract

This study gathered relevant evidence on the diversity of helminths parasitizing marsupials of the genus *Didelphis*, with emphasis on the main anatomical sites of infection. Based on the survey, it was possible to highlight that the digestive system presented the largest number of reports of parasitic findings by helminths, in which, when considering the descriptions of the organs/regions made by the authors, the stomach was the organ that presented the largest number of records (n=30) seen the studies of Babero (1960), Stewart & Dean (1971), Nettles *et al.* (1975), Gray & Anderson (1982), Bowman *et al.* (1983), Smith *et al.* (1983), Snyder *et al.* (1991), Ellis & Richardson (1999), Silva & Costa (1999), Matey *et al.* (2001), Mont-Mendoza & García-Prieto (2005), Nichelason *et al.* (2008), Díaz-Camacho *et al.* (2009), Nawa *et al.* (2009), Jiménez *et al.* (2011), Acosta-Virgen *et al.* (2015), Lópes-Crespo *et al.* (2017), Zabott *et al.* (2017), Torres-Montoya (2018), Costa-Neto (2019), Cardoso *et al.* (2021), Cirino *et al.* (2022), Vielmo *et al.* (2022), Freitas *et al.* (2022), Jiménes *et al.* (2024) and Panty-May (2024). This demonstrates not only the ability of helminths to reside in an organ with high digestive chemical activity, but also suggests the possibility of modulating and/or altering the stomach environment for their permanence.

As for the intestine, most studies differentiate the region where the parasitism occurs, such as the large intestine (n=23), small intestine (n=16) or cecum (n=14) seen in Crites (1956), Sandars (1958), Babero (1960), Nettles, Prestwood & Davidson (1975), Snyder *et al.* (1991), Ellis & Richardson (1999), Silva & Costa (1999), Cruz *et al.* (2000), Salgado-Maldonado & Cruz-Reyes (2002), Campbell *et al.* (2003), Mont-Mendoza & García-Prieto (2005), Chagas-Moutinho *et al.* (2007), Nichelason *et al.* (2008), Adnet *et al.* (2009), Nawa *et al.* (2009), Jiménez *et al.* (2011), Chagas-Moutinho *et al.* (2014), Acosta-Virgen

et al. (2015), Zabott *et al*. (2017), Costa-Neto (2019), Li (2019), Garcia-Varela *et al*. (2020), Cardoso *et al*. (2021), Ramírez-Cañas *et al*. (2021), Cirino *et al.* (2022), Vielmo *et al.* (2022), Freitas *et al*. (2022), Varella *et al*. (2022), Souza *et al*. (2022), Jiménes *et al*. (2024) & Panty-May *et al*. (2024).

Considering the results as a whole, the intestinal region is the most relevant for parasitism, apparently due to evolutionary characteristics as well as interest, since the intestinal environment allows for better absorption of nutrients. Furthermore, some authors do not make the proper distinction between the sites of infection and classify the intestinal region (n=7) in the case of Babero (1960), Cañeda-Guzmán *et al*. (2001), Mont-Mendoza & García-Prieto (2005), Acosta-Virgen *et al.* (2015) and Panty-May *et al*. (2024). The absence of this specific segmentation compromises the parasite-site of infection association. However, in more general terms, it confirms the potential related pathogens.

The data also indicate a significant infection in the cecum, a structure that acts as a reservoir for fecal content and a shelter for helminths such as *Trichuris* spp., which has already been reported in several studies. The recurring presence of these parasites suggests a persistent infection cycle, which may indicate chronic infestations in the hosts. This scenario may aggravate physiological impacts, such as changes in nutrient absorption and local inflammatory processes.

Pulmonary Region

Studies reporting parasitism in the pulmonary region are scarce, especially in bronchi and bronchioles, where the presence of *Heterostrongylus heterostrongylus* has been identified. However, the identification of helminths in the lungs was equally numerous (n=13) when compared to reports for the cecum and small intestine being recorded by Babero (1960), Nettles *et al*. (1975), Prestwood (1976), Prestwood *et al*. (1977), Ducan J.(1989), Snyder *et al*. (1991), Lamberski *et al*. (2002), Mont-Mendoza & García-Prieto (2005), Nichelason *et al*. (2008), Acosta-Virgen *et al*. (2015), Costa-Neto *et al*. (2016) and Cardoso *et al*. (2021). Among the records, the presence of *Didelphostrongylus hayesi* and *Capillaria* spp. has the potential to cause tissue damage, induce severe inflammatory responses, and compromise the respiratory performance of the hosts. This type of infection can reduce the animals' ability to escape from predators and increase their indirect mortality.

Hepatic and Biliary Region

Most reported findings in the liver were for *Gnathostoma turgidum* recorded by Mont-Mendoza & García-Prieto (2005), Díaz-Camacho *et al*. (2009), Nawa *et al*. (2009), Díaz-Camacho *et al*. (2010), Torres-Montoya *et al*. (2014), Acosta-Virgen *et al*. (2015) and Torres-Montoya (2018), however, Panty-May *et al*. (2024) recorded *Platynosomum illiciens*. While in the gallbladder only Sandars (1958) and Acosta-Virgen *et al*. (2015) described the presence of parasites, studies addressing this site of infection are scarce and relatively spaced.

Other Regions

Among the records in other regions/organic tissues (n=3), studies have identified parasites in the brain/encephalon by Sandars (1958), Kim *et al*. (2002) and Vielmo *et al*. (2022). There are reports of parasites in the oral mucosa (n=2) Pence & Little (1972) and Kinsella & Winegarner (1975), mesenteric arteries (n=1) by Miller *et al*. (2006), subcutaneous tissue (n=1) in the study by Cleveland *et al*. (2020), maxillary sinus (n=1) also by Sandars (1958), heart (n=1) by Babero (1960) and subcutaneous-neo-periesophageal connective tissue (n=1) Esslinger & Smith (1979). The occurrence of these parasites in noble systems suggests a capacity for migration or systemic dissemination and indicates migratory larval stages or accidental infections, with high pathogenic potential for the host.

Likewise, although it is less frequent, the presence of parasites in the subcutaneous tissue, oral mucosa, maxillary sinus, and periesophageal connective tissues, alerts us to the complexity of the parasite-host relationship. These unusual locations may be related to specific life cycles of some helminths or to infection in migratory larval stages.

Finally, the results discussed here reinforce the need for continued studies that integrate morphological, molecular, ecological and anatomopathological data on the parasite-host relationship of helminths found in opossums. Such investigations may not only expand parasitological knowledge but also support environmental control measures and preventive actions aimed at One Health that recognize opossums as important sentinels of the interface between fauna, environment and society.

The large number of records of helminths in the stomach and intestines raises hypotheses about possible synergisms or antagonisms between different species of parasites cohabiting the same host. Future studies may explore the dynamics of these interactions, which may affect the intensity of infection, pathogenicity and host immune

response. The fact that many studies do not accurately describe the location of helminths or omit specific anatomical data limits more refined comparisons. This methodological deficiency highlights the importance of standardization in the collection and recording of parasitological data as an essential component of systematic reviews such as the one developed in this work.

The bibliographic survey revealed the identification of a wide variety of parasites reported in various organs are regions of marsupials of the genus *Didelphis*, which demonstrates the degree of parasite-host relationship that these helminths have with animals. In addition, it raises important questions for public health, since some families (Capillariidae, Ascarididae and Strongilidae) and genera (*Trichuris* and *Gnathostoma*) are known to cause diseases in humans. Consequently, understanding the sites of infection and their dynamics with the host allows us to understand and investigate the possible complications that these parasites trigger, which may assist with management of these animals, as well as acting in the prevention of the transmission of zoonoses.

In terms of impact on the host, the infection sites analyzed suggest significant functional impairment, especially in digestive and respiratory structures. This may result in harm to the behavior, locomotion, reproductive capacity and survival of the animals, in addition to modifying their interaction with the ecosystem and with other species, including humans.

The identification of a significant portion of parasites in the digestive tract, where they are probably exploring specific ecological niches, suggests evolutionary adaptations that allow them to survive in specific conditions of each region/organ. The anatomical division observed in the records points to an ecological preference of the helminths related to the continuous supply of nutrients and the physiological environment favorable to their installation, development, and reproduction in the marsupials. Furthermore, the parasite-host relationship raises questions about the physiological and immunological impacts suffered by the opossums. Additionally, the effects of chronic parasitism can lead to both malnutrition and persistent inflammatory conditions, causing organ/tissue damage, directly affecting the host's quality of life.

Another relevant point refers to the coexistence of different groups of helminths in the same host. The large number of records of co-infection in organs such as the stomach and intestine indicate the possibility of synergistic or antagonistic interactions between these parasites. Such dynamics can influence the intensity of infection, pathogenicity and the animal's immune response. Competition for space and nutrients between cohabiting helminths, or even the induction of favorable environments by one species that benefits others are topics that deserve further study. These complex interactions broaden our understanding of parasitic ecology in marsupials and can provide support for the control of natural infections. Furthermore, the extra-gastrointestinal infections that indicate the migratory capacity of some larval forms, or the occurrence of accidental infections suggest mechanisms of systemic dissemination.

The findings also reflect the ecological importance of opossums as intermediate or definitive hosts of a wide variety of helminths, many of which have zoonotic potential. Genera such as *Trichuris*, *Gnathostoma*, *Capillaria* and *Angiostrongylus* are known to infect humans, which raises concerns regarding the interface between wildlife, urban environments and public health. The proposal of this study to compile the main infection sites and correlate them with the parasite-host relationship is pertinent in filling gaps regarding the anatomical distribution of parasites in *Didelphis* spp. This approach offers valuable support for studies of ecoparasitology, comparative parasite biology and zoonosis surveillance.

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