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ORIGINAL ARTICLE / ARTÌCULO ORIGINAL

ENDOPARASITES ASSOCIATED WITH ANURAN AMPHIBIANS IN A CONSERVATION AREA IN THE SETE CIDADES NATIONAL PARK, PIAUÍ STATE, BRAZIL

ENDOPARÁSITOS ASOCIADOS A ANFIBIOS ANUROS EN UN ÁREA DE CONSERVACIÓN DEL PARQUE NACIONAL DE SETE CIDADES, ESTADO DE PIAUÍ, BRASIL

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ABSTRACT

Inventories are the basis of studies, essential for determining which and how many species are part of an ecosystem and important for understanding the diversity and functioning of organisms. Studies on parasitic fauna are based on the importance of these organisms as disease-causing agents that can influence the biosecurity of ecosystems and natural environments. Thus, research that investigates the relationship between helminths and anurans provides information that helps in the conservation of these species and their habitats. The aim of this study is to describe the parasitic community associated with anuran amphibians in the Sete Cidades National Park (PNSC), an important conservation area in the north of the state of Piauí, Brazil. We analyzed 318 anuran amphibians, distributed among 21 species and four families. Of these, 142 individuals were parasitized by at least one species of endoparasite, giving an overall prevalence of 44.65%. A total of 8056 parasite specimens were counted and identified in 26 parasite taxa, with an average infection intensity of 56.73 and abundance of 25.33. Among the most abundant species found were *Raillietnema spectans* Gomes, 1964 (3034), *Schrankiana schranki* (Travassos, 1925) (2383), and *Aplectana hylambatis* (Baylis, 1927) (1540). In this study, we expanded the parasite fauna of anurans in the PNSC, which previously consisted of 13 parasite taxa in just four anuran species. Here, we recorded 21 additional parasite taxa, with new records of infection in 17 anuran host species. We also added 19 new parasite taxa to the existing records for the state of Piauí, significantly expanding our knowledge of the region.

Keywords: Anurans – Helminthes – Inventory – Nematodes – Semi-arid

RESUMEN

Los inventarios son la base de los estudios, esenciales para determinar cuáles y cuántas especies forman parte de un ecosistema e importantes para comprender la diversidad y el funcionamiento de los organismos. Los estudios sobre la fauna parasitaria se basan en la importancia de estos organismos como agentes causantes de enfermedades que pueden influir en la bioseguridad de los ecosistemas y entornos naturales. Así, las investigaciones que indagan en la relación entre helmintos y anuros proporcionan información que ayuda a la conservación de estas especies y sus hábitats. El objetivo de este estudio es describir la comunidad parasitaria asociada a anfibios anuros en el Parque Nacional de Sete Cidades (PNSC), una importante área de conservación en el norte del estado de Piauí. Analizamos 318 anfibios anuros, distribuidos entre 21 especies y cuatro familias. De ellos, 142 individuos estaban parasitados por al menos una especie de endoparásito, lo que supone una prevalencia global del 44,65%. Se contabilizaron un total de 8056 ejemplares parasitados y identificados en 26 taxones de parásitos, con una intensidad media de infección de 56,73 y una abundancia de 25,33. Entre las especies más abundantes se encontraron *Raillietnema spectans* Gomes, 1964 (3034), *Schrankiana schranki* (Travassos, 1925) (2383), y *Aplectana hylambatis* (Baylis, 1927) (1540). En este estudio, hemos ampliado la fauna de parásitos de anuros en el PNSC, que anteriormente constaba de 13 taxones de parásitos en sólo cuatro especies de anuros. Aquí, registramos 21 taxones de parásitos adicionales, con nuevos registros de infección en 17 especies de anuros hospedadores. También añadimos 19 nuevos taxones de parásitos a los registros existentes para el estado de Piauí, ampliando significativamente nuestro conocimiento de la región.

Palabras clave: Anuros – Helmintos – Inventario – Nematodos – Semiárido

INTRODUCTION

Amphibians are the vertebrates most at risk of extinction, with 40.7% of species threatened worldwide (Luedtke *et al.*, 2023). Emerging infectious diseases and habitat loss are currently the main causes of amphibian decline (Luedtke *et al*., 2023; Ruggeri *et al*., 2023). Amphibians are intermediate, paratenic, and/or definitive hosts for various species of parasitic helminths (Koprivnikar *et al*., 2012; Campião *et al*., 2014; Amorim *et al*., 2019; Herczeg *et al*., 2021; Mascarenhas *et al*., 2021). In this way, parasites can also cause species decline, affecting host immunity and population dynamics (Bittencourt & Rocha, 2003; Hudson, 2005).

The parasite fauna comprises a large part of the planet's biodiversity (Kuris, 2008), where parasitism is a complex ecological interaction that can involve ecological processes of multiple hosts (Bower *et al*., 2019) and can have a long history of coevolution between hosts and their parasites (Ebert & Fields, 2020). Among other things, they represent an important modulator of biodiversity at different trophic levels and are models for studying parasite-host relationships (Cardoso *et al*., 2016).

Inventories, which are the basis of studies, are essential for determining which and how many species are part of an ecosystem and are important for understanding the diversity and functioning of organisms (Segalla *et al*., 2021). Studies on parasitic fauna are based on the importance of these organisms as disease-causing agents that can influence the biosecurity of ecosystems and natural environments (Brooks & Hoberg, 2000). Thus, research investigating the relationship between helminths and anurans provides information that helps in the conservation of these species and their habitats (Coimbra *et al*., 2023). In addition to parasites having this ecological importance, anurans are also important as environmental bioindicators (Chaukulkar *et al*., 2018; Cramp & Franklin, 2018).

Helminths are the most common invertebrates parasitizing amphibians (Santos & Amato, 2013). Among these, the most abundant are nematodes (Campião *et al*., 2014; Oliveira *et al*., 2022) due to the biological aspects of the host and environmental conditions (Sena *et al*., 2018; Oliveira *et al*., 2022), where changes in natural ecosystems can cause variations in the transmission patterns of these parasites, facilitating their occurrence and dispersal (Poulin, 2007). These parasitic aspects are also closely related to the phylogeny and life history of the hosts (Poulin, 2007; Brito *et al*., 2014). Thus, many of the characteristics of the host habitat can influence colonization by parasites (Goater *et al*., 2005). This is due to how hosts respond to biotic factors such as temperature, humidity, precipitation, and others (Poulin & Krasnov, 2010).

Amphibian parasites can be directly affected by the environment, physiology, behavior, and ecology of their host (Bower *et al*., 2019). In amphibians, parasites can induce behavioral changes in their hosts that favor their establishment or transmission to their final host (Hernandez-Caballero *et al*., 2022). Stress-induced physiological changes can increase the host's vulnerability to parasitic infections (Herczeg *et al*., 2021), such as physiological responses caused by pesticides (Rohr *et al*., 2008; Hua *et al*., 2017). In addition, the presence and abundance of highly lethal parasites in amphibian populations may indicate susceptibility to disease and environmental disturbances (Koprivnikar, 2012).

However, according to Oliveira *et al*. (2023), parasites are distributed according to the dispersal of their hosts and are not directly influenced, as they are endoparasites, by the biotic factors that commonly limit the dispersal of other species. In this case, parasites are present in most anuran species. Knowledge of the diversity and distribution of parasites is therefore important for understanding the role of parasite-host ecological relationships in ecosystem dynamics (Poulin & Krasnov, 2010; Campião *et al*., 2015b).

Since there is a lack of information on the parasitic fauna of anuran amphibians in Piauí (Vieira *et al*., 2021), and given their impact on the ecology of populations and communities, the study of parasitism is important to understand the relationships between host and parasite, their impact on the trophic chain, and the influence of environmental factors on these relationships (Berkhout *et al*., 2019; Oliveira *et al*., 2023). Furthermore, helminths can also be used as bioindicators of environmental health (Koprivnikar *et al*., 2012). This study aims to describe the parasitic community associated with anuran amphibians in the Sete Cidades National Park (PNSC), an important conservation area in the state of Piauí, Brazil.

MATERIALS AND METHODS

Anuran amphibians were collected in the Sete Cidades National Park (PNSC), an environmental protection area located in the northern region of the state of Piauí (04°02-08‘S, 41°40-45’W), Brazil, which has an average altitude ranging from 100 and 290 meters (Ivanov & Lemos, 2020). The territory has typical characteristics of a transition zone, with areas of Caatinga and Cerrado (Della-Favera, 2002; Oliveira *et al*., 2010; Lopes *et al*., 2011). The anurans were collected at five sampling points throughout the park during the region's rainy season, using auditory and visual searches (Heyer *et al*., 1994), during 19 collection days between March and May 2024, from 18:00 to 00:00.

In the laboratory, the anurans were euthanized with a lethal injection of thiopental sodium (Thiopentax®), fixed in 10% formaldehyde, and preserved in 70% alcohol. They were necropsied with ventral incisions in the anteroposterior axis, and the following organs were analyzed using a stereoscopic microscope: gastrointestinal tract, lungs, liver, kidneys, and internal cavity. The parasites were collected and prepared according to Amato *et al*. (1991). The parasites were identified according to the specific methodology for each taxonomic group, using the following literature: Yamaguti (1971), Schmidt (1986), Vicente *et al*. (1991), and Felix-Nascimento *et al*. (2020). The infection parameters were analyzed according to Bush *et al*. (1997). The endoparasites identified were deposited in the Parasitological Collection of the Federal University of Ceará (CPUFC; voucher: 1087 – 1112), Fortaleza, Brazil, and their hosts in the Herpetological Collection of the Federal University of Ceará (CHUFC; voucher: PN7C 01 – PN7C 318), Fortaleza, Brazil. We used a linear model to verify the relationship between host size (snout-vent length-SVL) and final parasite abundance.

Ethic aspects: All the procedures used in this work comply with the ethical standards of the relevant national and institutional guidelines on the care and use of laboratory animals. Collection authorization Chico Mendes Institute for Biodiversity

Conservation - ICMBio (#92796-1) and Ethics Committee on the Use of Animals of the Federal University of Ceará (CEUA-UFC) (#CEUA 6314010321).

RESULTS

We analyzed 318 anuran amphibians, distributed among 21 species and four families. Of these, 142 individuals were parasitized by at least one endoparasite species, with an overall prevalence of 44.65% (see Table 1). A total of 8,056 parasite specimens were counted and identified in 26 parasite taxa, with an average infection intensity of 56.73 and abundance of 25.33. Among the most abundant species found were *Raillietnema spectans* Gomes, 1964 (3,034 individuals), *Schrankiana schranki* (Travassos, 1925) (2,383 individuals), and *Aplectana hylambatis* Baylis, 1925 (1,540 individuals).

Leptodactylidae was the family with the largest number of parasites, with an average of seven parasite species per host analyzed. *Leptodactylus fuscus* (Schneider, 1799) was the species with the greatest diversity of parasite species identified (12 spp.). The parasitic fauna of anurans in the SCNP was previously composed of 13 parasite taxa, in only four anuran species. Here, we recorded 21 additional parasite taxa, with new infection records in 17 anuran host species. In addition, we added 19 new parasite taxa to the existing records for the state of Piauí, significantly expanding knowledge about the region. Also analyzing the influence of the SVL on parasite abundance, identifying that for the endoparasitic community, the size of the host is an influential factor in the expected final richness (R2 = 0.37; $p < 0,001$).

DISCUSSION

Amphibians are excellent models for studies investigating the diversity of parasitic communities (Aho, 1990; Campião *et al*., 2015b). The fauna of endoparasites associated with anurans is rich and diverse, being characterized by a wide distribution and low host specificity (Campião *et al*., 2014). It has a strong tendency to increase considerably as new areas and new available hosts are sampled (Campião *et al*., 2015b).

According to Campião *et al*. (2014), around 90% of Brazilian anurans have not yet been studied regarding their parasite fauna, with anurans from the Hylidae and Leptodactylidae families being the most frequently studied hosts. Commonly, nematodes and trematodes are the most recorded in these amphibians (Campião *et al*., 2014). Campião *et al*. (2015b) claim that leptodactylids have rich parasite communities, with a great taxonomic diversity, mainly composed of nematodes. In our results, leptodactylid species presented the highest prevalence, diversity, and parasite richness. We also observed that most that infections were caused by nematodes, which seems to be a pattern common to species of this family, corroborated by several other studies (see Teles *et al*., 2015; Oliveira *et al*., 2019, 2022).

As for the low parasite prevalence found in some host species, Chandra & Gupta (2007) highlight that habitat characteristics can influence the composition and structure of the helminth fauna associated with amphibians, which are generally associated with two types of environments (aquatic and terrestrial). Thus, terrestrial species are more likely to come into direct contact with infective larvae than arboreal species, which allows a greater variety of parasites to settle in these animals (Chandra & Gupta, 2007). Thus, one factor that may explain this low prevalence is the host's use of the habitat and the direct transmission of the parasite subcutaneously. Another point is the fact that some species show aestivation behavior and have explosive reproduction, which may have made it difficult for the species to find infective larvae and thus influenced these results.

Overall, the PNSC showed a high diversity of parasitic species infecting anurans (26 taxa). The richness found in this study is similar to other studies dealing with the helminth community associated with anurans (Campião *et al*., 2016a; Graça *et al*., 2017), as well as in other conservation areas such as the Environmental Protection Area (APA) of Serra de Maranguape (Oliveira *et al*., 2022) and the APA of Bica do Ipu (Silva-Neta *et al*., 2020). However, this richness may still be underestimated due to unidentified species, such as the occurrence of cryptic species, such as in Rhabdiasidae (Müller *et al*., 2018), or species that were not feasible to identify.

In the last decade, several studies on parasitism in Brazilian amphibians have been carried out (Teles *et al*., 2015; Graça *et al*., 2017; Silva *et al*., 2019; Mascarenhas *et al*., 2021; Oliveira *et al*., 2024; Santos *et al*., 2024). Even so, for the PNSC only the species *Dermatonotus muelleri* (Boettger, 1885), *Leptodactylus vastus* Lutz, 1930, *Rhinella diptycha* (Cope, 1862), and *Trachycephalus typhonius* (Linnaeus, 1758) have their helminth fauna known (Benício *et al*., 2022). According to Aguiar *et al*. (2014), with the increase in parasitological studies, especially in areas that have not yet been sampled and hosts that have not been studied much, it is common to find new records of parasites that have not yet been reported for host species.

A good example is *Physalaemus cuvieri* (Fitzinger, 1826*)*, a species widely distributed throughout Brazil (Segalla *et al*., 2021) and well-known for parasite studies throughout its distribution (see Santos & Amato, 2013; Aguiar *et al*., 2015; Graça *et al*., 2017; Oliveira *et al*., 2019; Silva-Neta *et al*., 2020; Aguiar *et al*., 2021; Sani *et al*., 2021; Oliveira *et al*., 2022). We still present in our results the first record of infection of *Physalopteroides venancioi* Lent, Freitas & Proença, 1946 and *Oxyascaris* sp. for this host. We also presented 33 new records of parasite infection for 14 species of new hosts and added 19 taxa to the records already known for the state of Piauí. Our study corroborates the results of Aguiar *et al*. (2014), that it is common to find new records of parasites in widely studied species, and highlights the need for more parasitological work with host species throughout their distribution and in areas that are still little known since parasite diversity and the parasite-host relationship are still far from being truly known.

Nematodes are diverse, abundant, generalist, and well-distributed in the environment. They have a direct life cycle and reach their hosts through oral ingestion or active penetration of infective larvae through the skin (Anderson, 2000). In this study, 69% of the parasites identified were Nematoda, following the same pattern of infection found in other neotropical anurans (Campião *et al*., 2016a; Graça *et al*., 2017; Oliveira *et al*., 2019; Silva-Neta *et al*., 2020; Mascarenhas *et al*., 2021; Oliveira *et al*., 2022).

Monoxenous parasites such as *R. spectans*, *S. schranki*, and *A. hylambatis* were the most abundant species. However, *Cosmocerca podicipinus* Baker & Vaucher, 1984, *R. spectans*, and *Oswaldocruzia mazzai* Travassos, 1935 were the species that most infected different hosts. According to Anderson (2000), parasites with direct life cycles have low specificity and a simple mode of transmission, which can occur through the ingestion of eggs or penetration of larvae through the host's skin. The high abundance of some parasite species may be associated with parasite self-infection due to the reproduction of these parasites in their hosts (Anderson, 2000). In addition, these species have been recorded infecting several Neotropical anurans (Campião *et al*., 2014; Teles *et al*., 2015; Alcantara *et al*., 2018; Oliveira *et al*., 2019). Possibly the wide distribution of these parasites and their generalist habitats in terms of host selection (Campião *et al*., 2014, 2015b; Oliveira *et al*., 2019, 2023) are also responsible for the high infection rates.

A significant number of parasitic larvae have been found in the small and/or large intestines of various host species. Larvae of this type are commonly found in amphibian species (Campião *et al*., 2014; Oliveira *et al*., 2022), and this larval stage may be associated with the parasite's monoxenic cycle (Anderson, 2000), as well as a possible recent infection and/or reproduction of the adult parasites in the host. As for the large number of unidentified female specimens, this is due to the lack of taxonomic characters that would enable identification, often caused during the fixation of the hosts previously. In addition, the lack of taxonomic studies is also a limiting factor for the accurate identification of some parasite species distributed in the region studied (Felix-Nascimento *et al*., 2020).

The species of *Centrorhynchus* and *Oligacanthorhynchus* are heteroxenous and generally have mammals and/or birds as definitive hosts (Smales, 2007; Richardson *et al*., 2014), with amphibians being paratenic hosts (Yamaguti, 1963). In South America, *Oligacanthorhynchus* sp. has been recorded infecting *Odontophrynus americanus* (Duméril & Bibron, 1841) (Campião *et al*., 2014), *Pleurodema diplolister* (Peters, 1870) (Silva-Neta *et al*., 2020), and *L. vastus* (Oliveira *et al*., 2022). In the present study, *Oligacanthorhynchus* sp. was recorded parasitizing *Leptodactylus macrosternum* Miranda-Ribeiro, 1926.

In amphibians, only the ascarid species *Brevimulticaecum* sp. and *Porrocaecum* sp. are recorded for these hosts (González & Hamann, 2013; Campião *et al*., 2016a). We identified 21 individuals of *Brevimulticaecum* sp. parasitizing the species *L. macrosternum* and *Dendropsophus minusculus* (Rivero, 1971), and two individuals of *Porrocaecum* sp. infecting *L. fuscus*. Ascarids of this type have been reported parasitizing fish, reptiles, and amphibians (Vieira *et al*., 2010). However, these parasites have crocodilians, freshwater rays, and teleosts as their definitive hosts in the life cycle (Goldberg et al., 2007; Reyda, 2008), while amphibians function as intermediate hosts. This is the first record of *Brevimulticaecum* sp. infection in *D. minusculus* (Rivero, 1971), however, due to the larval stage of this parasite, it was not possible to identify it at the species level.

The *Strongyloides* Grassi, 1879 genus has a low specificity and has already been reported for a variety of anurans such as *Boana raniceps* (Cope, 1862), *Physalaemus albonotatus* (Steindachner, 1864), *Physalaemus cuvieri* Fitzinger, 1826, *Pithecopus gonzagai* Andrade, Haga, Ferreira, Recco-Pimentel, Toledo & Bruschi, 2020, *Pristimantis relictus* Roberto, Loebmann & Ávila, 2022, *Scinax x-signatus* (Spix, 1824), *T. typhonius*, *Leptodactylus gracilis* (Duméril & Bibron, 1841), *Rhinella dorbignyi* (Duméril & Bibron, 1841), *Rhinella icterica* (Spix, 1824), and *Proceratophrys ararype* Mângia, Koroiva, Nunes, Roberto, Ávila, Sant'Anna, Santana & Garda, 2018 (Campião *et al*., 2014; Mascarenhas *et al*., 2021; Oliveira *et al*., 2022). Although its biology is not detailed, it is known that these parasites commonly have a direct life cycle; infection occurs through dermal penetration and ingestion of infected prey (Mati & Melo, 2014; Sulieman *et al*., 2015). However, even though these parasites are capable of infecting several anuran species (Campião *et al*., 2014), they generally show low infection rates, as observed in this study for *P. cuvieri*.

The Cestoda *Cylindrotaenia americana* Jewell, 1916 has been recorded in several amphibians in Brazil (Toledo *et al*., 2013; Oliveira *et al*., 2019, Silva-Neta *et al*., 2020; Oliveira *et al*., 2022). In the Caatinga, the first record of *C. americana* was made for *Physalaemus cicada* Bokermann, 1966 (Oliveira *et al*., 2019), later in *P. diplolister* in high-altitude swamps inserted in the Caatinga (Silva-Neta *et al*., 2020). In our results, we recorded *C. americana* parasitizing *P. diplolister* in Cerrado areas. In Brazil, there are few records of monogeneans, the majority being reported for the genus *Polystoma* Zeder, 1800 (Santos & Amato, 2012). This is the best-known genus among the Polystomatidae (Sinnappah *et al*., 2001), with a direct life cycle that can be completed in the gills of young tadpoles or inside the urinary bladder of adult frogs (Bentz *et al*., 2006). Here, we report specimens of *Polystoma goeldii* Sales, Du Preez, Verneau & Domingues, 2023 infecting *Leptodactylus troglodytes* A. Lutz, 1926 and *Leptodactylus vastus* A. Lutz, 1930, this being the first record for the host species and the expansion of the parasite's distribution area (Pará state) to the state of Piauí.

Several studies report that host body size can influence the establishment of parasite communities (Campião *et al*., 2015a; Silva-Neta *et al*., 2020). Larger individuals generally offer larger colonization areas, providing adequate resources for parasite development and reproduction (Campião *et al*., 2015a; 2016b). However, Oliveira *et al*. (2023) report that host size is only influential when there is significant size variation among individuals. In the present study, the size of anuran hosts was a determining factor in parasite abundance; this fact may be related to the larger surface area available for colonization (Toledo *et al*., 2017).

In our study, we demonstrated that the endoparasites composition of anurans from the PNSC follows the common pattern described for Neotropical amphibians, presenting high species richness and prevalence, with a strong relationship between abundance and host size. We also expanded the parasitological knowledge for the region and added new parasite taxa to the existing records for the Piauí state, highlighting the importance of amphibians as models for parasite studies. In addition, we reaffirm the importance of parasite inventories for host species in poorly studied regions, considering the need to significantly expand knowledge about parasitism in amphibians.

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Table 1. List of endoparasites found in anuran hosts of the Sete Cidades National Park (PNSC), Piauí state, northeastern Brazil, and indication of new infection records. N = number of hosts; NH = number of parasites; P% = prevalence; MII + R = mean intensity of infection + range; AB + SE = abundance + standard error.

Host (N)	Parasite (NH)	P%	MII + A	AB + SE	Reference
Bufonidae					
Rhinella diptycha (18)		**66.67**	**16.17 (1 - 84)**	**10.78 + 0.56**	
	Aplectana hylambatis (2)	5.56	2	0.11	New record
	Ochoterenella sp. (1)	5.56	1	0.06	Aguiar *et al*. (2021); Benício *et al*. (2022)
	Oswaldocruzia mazzai (157)	22.22	39.25 (5 - 84)	8.72 + 3.29	Aguiar *et al*. (2021); Oliveira *et al*. (2022)
	Physaloptera sp. (2)	11.11	1	0.11	Amorim *et al*. (2019); Oliveira *et al*. (2022)
	Raillietnema spectans (5)	5.56	5	0.27	Amorim *et al*. (2019); Oliveira *et al*. (2022)
	Rhabdias sp. (12)	5.56	12	0.67	Amorim *et al.* (2019); Aguiar *et al.* (2021); Oliveira *et al*. (2022)
	Cosmocercidae female (13)	38.89	1.86 (1 - 3)	0.72 + 0.18	-
	Ascarididae larva (4)	5.56	4	0.22	-
Hylidae					
Boana raniceps (4)		**50**	**3 (1 - 5)**	**1.5 + 0.87**	
	Physalopteroides venancioi (6)	50	3 (1 - 5)	1.5 + 0.87	Campião *et al*. (2016a); Oliveira *et al*. (2022)

Dendropsophus minusculus (14)		**14.29**	**4 (1 - 6)**	**0.57 + 0.09**	
	Brevimulticaecum sp. (6)	7.14	6	0.42	New record
	Physocephalus sp. (1)	7.14	1	0.07	New record
	Centrorhynchus sp. (1)	7.14	1	0.07	Oliveira *et al*. (2022)
Dendropsophus minutus (33)		**3.03**	**4 (1 - 3)**	**0.12**	
	Centrorhynchus sp. (3)	3.03	3	0.09	Oliveira *et al*. (2022)
	Nematoda larva (1)	3.03	1	0.03	-
Dendropsophus soaresi (3)	Not parasitized				
Scinax fuscomarginatus (29)		**17.24**	**4.8 (1 - 8)**	**0.83 + 0.34**	
	Cosmocerca podicipinus (1)	3.45	1	0.03	Campião *et al*. (2014)
	Centrorhynchus sp. (23)	13.79	5.75 (5 - 8)	0.79 + 0.68	Aguiar *et al*. (2021)
Scinax nebulosus (3)		**33.33**	**1**	**0.33**	
	Centrorhynchus sp. (1)	33.33	1	0.33	Campião *et al*. (2014)
Scinax similis (32)		**15.63**	**3.4 (1 - 5)**	**0.53 + 0.09**	
	Oxyascaris caudacutus (6)	9.38	2 (1 - 4)	0.19 + 0.06	New record
	Cosmocercidae female (11)	9.38	3.67 (2 - 5)	0.34 + 0.11	-
Scinax x-signatus (6)		**33.33**	**1.5 (1 - 2)**	**0.50 + 0.17**	
	Ochoterenella sp. (2)	16.67	2	0.33	New record
	Cosmocercidae female (1)	16.67	1	0.16	-
Leptodactylidae					
Adenomera juikitam (3)		**33.33**	**1**	**0.33**	
	Centrorhynchus sp. (1)	33.33	1	0.33	New record
Leptodactylus fuscus (31)		**90.32**	**46.07 (1 - 216)**	**41.61 + 1.12**	
	Cosmocerca parva (14)	3.23	14	0.45	Morais (2013); Campião *et al.* (2014)
	Cosmocerca podicipinus (21)	12.9	5.25 (1 - 16)	0.68 + 0.21	Campião *et al.* (2014)
	Oswaldocruzia mazzai (3)	3.23	3	0.1	Campião *et al*. (2014)

	Oxyascaris catingae (17)	12.9	4.25 (2 - 8)	0.55 + 0.17	New record
	Physaloptera sp. (7)	9.68	2.33 (2 - 3)	0.23 + 0.07	Morais (2013); Oliveira *et al*. (2022)
	Physalopteroides venancioi (2)	3.23	2	0.06	Campião *et al*. (2016a)
	Porrocaecum sp. (2)	3.23	2	0.06	Campião *et al*. (2016a)
	Raillietnema spectans (264)	22.58	37.71 (16 - 57)	8.52 + 2.37	Silva-Neta *et al.* (2020); Oliveira *et al*. (2022)
	Rhabdias sp. (3)	3.23	3	0.1	Cañizales (2021); Oliveira *et al*. (2022)
	Schrankiana schranki (926)	48.39	61.73 (2 - 216)	29.87 + 6.40	Morais (2013); Oliveira *et al*. (2022)
	Cosmocercidae female (30)	19.35	4.83 (1 - 16)	0.94 + 0.28	-
	Cosmocercidae larva (3)	6.45	1.50 (1 - 2)	0.1	-
Leptodactylus macrosternum (7)		**100**	**19.14 (1 - 27)**	**19.14 + 1.09**	
	Aplectana hylambatis (5)	14.29	5	0.71	New record
	Brevimulticaecum sp. (15)	28.57	7.5 (2 - 13)	2.14 + 1.17	Goldberg *et al*. (2007)
	Cosmocerca podicipinus (15)	28.57	7.5 (3 - 12)	2.14 + 1.16	Campião *et al*. (2014)
	Oswaldocruzia mazzai (4)	14.29	4	0.57	Silva-Neta *et al*. (2020); Oliveira *et al*. (2022)
	Oxyascaris sp. (2)	14.29	2	0.29	New record
	Physalopteroides venancioi (37)	71.42	7.4 (2 - 10)	5.28 + 1.49	Morais (2013); Campião *et al*. (2016a)
	Raillietnema spectans (27)	14.29	27	3.85	New record
	Cosmocercidae female (4)	28.57	2	0.57	-
	Centrorhynchus sp. (2)	14.29	2	0.29	Campião *et al*. (2014)
	Oligacanthorhynchus sp. (23)	14.29	23	3.28	New record
Leptodactylus mystaceus (4)		**75**	**4 (2 - 8)**	**3 + 0.94**	

	Cosmocerca podicipinus (10)	50	5 (2 - 8)	2.5 + 1.38	New record
	Oxyascaris catingae (2)	25	2	0.5	New record
Leptodactylus pustulatus (4)		**80**	**2.5 (1 -4)**	**2 + 0.34**	
	Cosmocerca podicipinus (3)	20	3	0,6	Campião *et al*. (2014)
	Physaloptera sp. (1)	20	1	0.2	Morais (2013); Oliveira *et al*. (2022)
	Nematoda larva (2)	40	1	0.4	-
	Centrorhynchus sp. (4)	20	4	0.8	Oliveira *et al*. (2024); Santos *et al*. (2024)
Leptodactylus troglodytes (16)		**75**	**15.75 (1 - 47)**	**11.81 + 0.61**	
	Aplectana hylambatis (13)	6.25	13	0,81	New record
	Cosmocerca podicipinus (35)	25	8.75 (5 - 19)	2.18 + 0.82	New record
	Oxyascaris sp. (2)	6.25	2	0.12	New record
	Raillietnema spectans (94)	31.25	18.8 (5 - 47)	5.87 + 2.04	Oliveira *et al*. (2022)
	Physaloptera sp. (6)	12.5	3 (1 - 5)	0.37 + 0.16	New record
	Polystoma goeldii (1)	6.25	1	0.06	New record
	Cosmocercidae larva (19)	12.5	9.5 (7 - 12)	1.18 + 0,52	-
	Cosmocercidae female (19)	43.75	2.71 (1 -9)	1.18 + 0.36	-
Leptodactylus vastus (18)		**100**	**331.61 (1 - 654)**	**331.61 + 12.08**	
	Aplectana hylambatis (1533)	38.89	219 (66 - 461)	85.17 + 27.11	New record
	Cosmocerca sp. (49)	5.55	49	2.72	New record
	Oswaldocruzia mazzai (5)	11.11	2.5 (1 - 4)	0.28 + 0.11	Silva-Neta *et al*. (2020); Oliveira *et al*. (2022)
	Physaloptera sp. (34)	22.22	8.5 (2 - 19)	1.89 + 0.69	Oliveira *et al*. (2022)
	Physalopteroides venancioi (1)	5.56	1	0.05	New record
	Raillietnema spectans (2570)	77.78	183.57 (1 - 648)	142.78 + 33.90	Benício *et al*. (2022); Oliveira *et al*. (2022)

	Rhabdias sp. (295)	55.56	29.5 (1 - 102)	16.39 + 5.05	Oliveira *et al*. (2022)
	Schrankiana schranki (1454)	16.67	484.67 (200 - 654)	80.78 + 31.73	Campião *et al.* (2014); Oliveira *et al*. (2022)
	Ascarididae larva (1)	5.55	1	0.05	-
	Centrorhynchus sp. (3)	5.55	3	0.17	Oliveira *et al*. (2022)
	Polystoma goeldii (8)	16.66	2.66 (1 - 6)	0.44 + 0.17	New record
Physalaemus cuvieri (22)		**72.73**	**9.56 (1 - 25)**	**6.95 + 0.36**	
	Cosmocerca podicipinus (139)	59.1	10.70 (1 - 25)	6.31 + 1.27	Oliveira *et al*. (2022)
	Oswaldocruzia mazzai (1)	4.55	1	0.05	Oliveira *et al*. (2019)
	Oxyascaris sp. (3)	4.55	3	0.13	New record
	Physalopteroides venancioi (1)	4.55	1	0.05	New record
	Strongyloides sp. (4)	9.1	2 (1 - 3)	0.18	Oliveira *et al*. (2022)
	Cosmocercidae larva (4)	9.1	2	0.18	-
	Nematoda larva (1)	4.55	1	0.05	-
Pleurodema diplolister (31)		**35.48**	**2.91 (1 - 5)**	**1.03 + 0.05**	
	Ochoterenella sp. (1)	3.23	1	0.03	Silva-Neta *et al*. (2020)
	Oxyascaris catingae (13)	22.58	1.85 (1 - 4)	0.42 + 0.12	New record
	Physaloptera sp. (6)	9.68	2 (1 - 4)	0.19 + 0.06	New record
	Raillietnema spectans (1)	3.23	1	0.03	Silva-Neta *et al*. (2020)
	Schrankiana schranki (3)	3.23	3	0.1	New record
	Cosmocercidae female (2)	6.45	1	0.06	-
	Cylindrotaenia americana (6)	6.45	3 (1 - 5)	0.19	Silva-Neta *et al*. (2020)
Pseudopaludicola mystacalis (34)		**32.35**	**1.82 (1 - 3)**	**0.59 + 0.04**	
	Cosmocerca parva (2)	5.88	1	0.06	New record
	Cosmocerca podicipinus (11)	23.53	1.38 (1 - 3)	0.32 + 0.18	New record
	Oxyascaris sp. (3)	5.88	1.50 (1 - 2)	0.09	New record
	Physaloptera sp. (1)	2.94	1	0.03	Silva-Neta *et al*. (2020)

	Rhabdias sp. (1)	2.94	1	0.03	New record
	Cosmocercidae female (1)	2.94	1	0.03	-
	Centrorhynchus sp. (1)	2.94	1	0.03	New record
Microhylidae					
Elachistocleis piauiensis (3)	Not parasitized				
Odontophrynidae					
Proceratophrys cristiceps (3)		**33.33**	**1**	**0.33**	
	Cosmocerca sp. (1)	33.33	1	0.33	New record