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ORIGINAL ARTICLE / ARTÍCULO ORIGINAL

Diversity of parasitic helminths associated with lizards in a little studied environment in the Caatinga domain, northeastern Brazil

Diversidad de helmintos parásitos asociados con lagartos en un entorno poco estudiado del dominio de la Caatinga, en el noreste de Brasil

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ABSTRACT

This study presents the composition of the helminth community and the parameters of parasitic infection (abundance, prevalence, mean intensity of infection) of five species of lizards collected in an area of Carrasco in the Northeast region of Brazil. Collections were made between May and September 2021 in a carrasco environment located in Chapada do Araripe, Ceará state, Brazil. Specimens were captured using traps and also manually during active searches. The parasites found were collected and infection patterns estimated for each species. A total of 239 parasites were collected from 21 hosts. The community was predominantly composed of nematodes. The lizard *Phyllopezus pollicaris* (Spix, 1825) had the highest parasitic diversity, and the nematode species *S. oxkutzcabiensis* Chitwood, 1938 was the most prevalent in the community. Most nematode species were found in the gastrointestinal tract of the hosts. Parasitic members of the Pharyngodonidae family were the most common nematodes found. We found strong similarities in the composition and distribution of endoparasite species in the Carrasco and the adjacent Caatinga environments. The endoparasite community recorded was diverse, and some nematode species were associated with specific host species. The lizards *E. bibronii* Boulenger, 1885 Boulenger, 1885 and *P. pollicaris* are recorded here as new hosts for Onchocercidae and *P. travassosi* Pereira, 1935, respectvely. The data presented here provide

new information, expanding knowledge about the composition of the helminthological fauna of lizards occurring in the Caatinga.

Keywords: Carrasco – Helminth fauna – Nematoda – Neotropical region

RESUMEN

Este estudio presenta la composición de la comunidad de helmintos y los parámetros de infección parasitaria (abundancia, prevalencia, intensidad media de la infección) de cinco especies de lagartos recogidos en una zona de Carrasco, en la región noreste de Brasil. Las recolecciones se realizaron entre mayo y septiembre de 2021 en un entorno de carrasco situado en Chapada do Araripe, estado de Ceará, Brasil. Los especímenes se capturaron utilizando trampas y también manualmente durante búsquedas activas. Se recolectaron los parásitos encontrados y se estimaron los patrones de infección para cada especie. Se recolectaron un total de 239 parásitos de 21 huéspedes. La comunidad estaba compuesta predominantemente por nematodos. El lagarto *Phyllopezus pollicaris* (Spix, 1825) presentó la mayor diversidad parasitaria, y la especie de nematodo *S. oxkutzcabiensis* Chitwood, 1938 fue la más prevalente en la comunidad. La mayoría de las especies de nematodos se encontraron en el tracto gastrointestinal de los huéspedes. Los miembros parásitos de la familia Pharyngodonidae fueron los nematodos más comunes encontrados. Encontramos fuertes similitudes en la composición y distribución de las especies de endoparásitos en los entornos de Carrasco y la Caatinga adyacente. La comunidad de endoparásitos registrada era diversa, y algunas especies de nematodos estaban asociadas a especies hospedadoras específicas. Los lagartos *E. bibronii* Boulenger, 1885 Boulenger, 1885 y *P. pollicaris* se registran aquí como nuevos hospedadores de Onchocercidae y *P. travassosi* Pereira, 1935, respectivamente. Los datos aquí presentados proporcionan nueva información, ampliando el conocimiento sobre la composición de la fauna helmintológica de los lagartos que habitan en la Caatinga.

Palabras clave: Carrasco – Fauna helmíntica – Nematoda – Región neotropical

INTRODUCTION

Helminths comprise a group of endoparasites that infect the internal organs of various groups of vertebrates and invertebrates (Hamann *et al*., 2006a,b; Rodrigues *et al*., 2006; Ávila *et al*., 2012). They are discrete components of biodiversity capable of significantly impacting their hosts and the communities in wich they live (Bezerra *et al.*, 2016). Among vertebrates, notable efforts have been made to discover the diversity of helminths that parasitize lizards (Ávila & Silva, 2010; Lacerda *et al*., 2023), and knowledge about endoparasites associated with this group has increased in many aspects, from records of new hosts and locations, composition and structure of the parasitic fauna, geographical distribution, and description of new species (Ávila & Silva, 2010; Pereira *et al*., 2011, 2012, 2014, De Oliveira Sousa *et al*., 2021, Ferreira *et al.,* 2021; Lacerda *et al.,* 2023, Oitaven *et al*., 2023).

The northeast of Brazil is home to around 295 species of lizards (Guedes *et al*., 2023). They interact with a wide variety of other organisms, are key components of ecological communities, and are considered good models for studies, especially in parasitological research (Aho, 1990; Pianka & Vitt, 2003; Ávila *et al*., 2012). The fauna of helminths associated with reptiles in Northeast Brazil is rich and very diverse, and mostly represented by nematodes recorded mainly in lizards (Lacerda *et al*., 2023). The parasitic fauna that can be harbored by this group varies considerably in terms of compostion and abundance, for example, with these variations being related to factors such as temporal variation, sexual differences, host size, diet, as well as environmental conditions and the life cycle of parasitic species (Pianka & Vitt, 2003; Thieltges *et al*., 2008; Brito *et al*., 2014; Teles *et al*., 2017). In addition to factors such as phylogenetic relationships, variations in habitat use, and seasonality, can result in a diverse component community (Bush *et al*., 1995; Araujo-Filho *et al*., 2017, 2020, Cabral *et al*., 2018).

The Brazilian Northeast has a wide diversity and distribution of lizards (Oitaven *et al*., 2023), and although they are the most studied group (Ávila *et al*., 2012; Lacerda *et al*., 2023) some species go “unnoticed” (Silva Neta & Ávila, 2018), producing a panorama where some are better represented, while others are generally undersampled, making their parasitic communities sometimes little know. The vast territorial extension of the northeast region presents great variations in relief, and several atmospheric circulation systems overlap, causing differences in

continentality and maritime conditions. Thus, the climatic conditions of the region are quite complex (Nimer, 1966, 1972) and this is reflected in the presence of a wide variety of vegetation types.

The term carrasco is used to designate different types of vegetation in northeastern Brazil and beyond, covering areas such as scrubland and open vegetation with small shrubs (Araújo *et al*., 1998). Carrasco is a type of vegetation that occurs throughout the central-western area of Chapada do Araripe. It has a dense shrubby appearance and covers areas of the plateau between 700 and 900 meters above sea level (Loiola *et al*., 2015). This type of vegetation also occupies a narrow strip along the Ibiapaba plateau, extending from north to south, on the border between the states of Ceará and Piauí (Araújo *et al.,* 1999). The carrasco is characterized by very dense xerophytic vegetation, found in high altitude areas in the Caatinga domain, but considered a distinct environment due to its climatic composition and phytophysiognomy (Andrarde-Lima, 1978; Sousa *et al.,* 2014), being little know not only in relation to its fauna but also to the diversity of parasites associated with reptilian hosts that occur in this environment.

This study presents the composition of the helminth community and the parameters of parasitic infection (abundande, prevalence, mean infection intensity) of five species of lizards collected in a scrubland area in northeastern Brazil. The data presented here are important for enriching existing knowledge about parasitic helminths associated with lizards inhabiting different areas of the Brazilian northeastern Caatinga.

MATERIAL AND METHODS

Study area

The lizards were collected at the Minguiriba site (7°18’59”S 39°37’22”W), a rural community belonging to the municipality of Crato, state of Ceará, Northeast Brazil (Fig. 1), located in the eastern portion of Chapada do Araripe, within an area of Carrasco on the edge of the Floresta Nacional do Araripe (FLONA-Araripe). Carrasco is decribed as a type of environment characterized by very dense xerophytic vegetation, composed of Caatinga and Cerrado species, consiting predominantly of branched shrubs with large, thin stems, rarely

thorny and spaced trees (Araújo *et al*., 1998). It can found in pleateu areas, such as the Ibiapaba plateau, on the border between the states of Ceará and Piauí, and the Chapada do Araripe, on the border between the states of Ceará and Pernambuco, occupying an altitudinal range of 700 to 900m (Araújo *et al*., 1998).

The Carrasco, which is concentrated in the Chapada do Araripe, is bordered by the mountain rainforest, the xeromorphic subdeciduous tropical forest, and the Caatinga to the northeast, the Cerrado sensu stricto to the southeast, the Caatinga to the west, and the dry forest to the south (Araújo *et al.,* 1998, De Oliveira Sousa *et al.,* 2021). The climate in the area is classified as humid and dry tropical (De Oliveira Sousa *et al*., 2021), and dry, sandy soil, composed of deep, low-fertility quartz sands (Araújo *et al*., 1999).

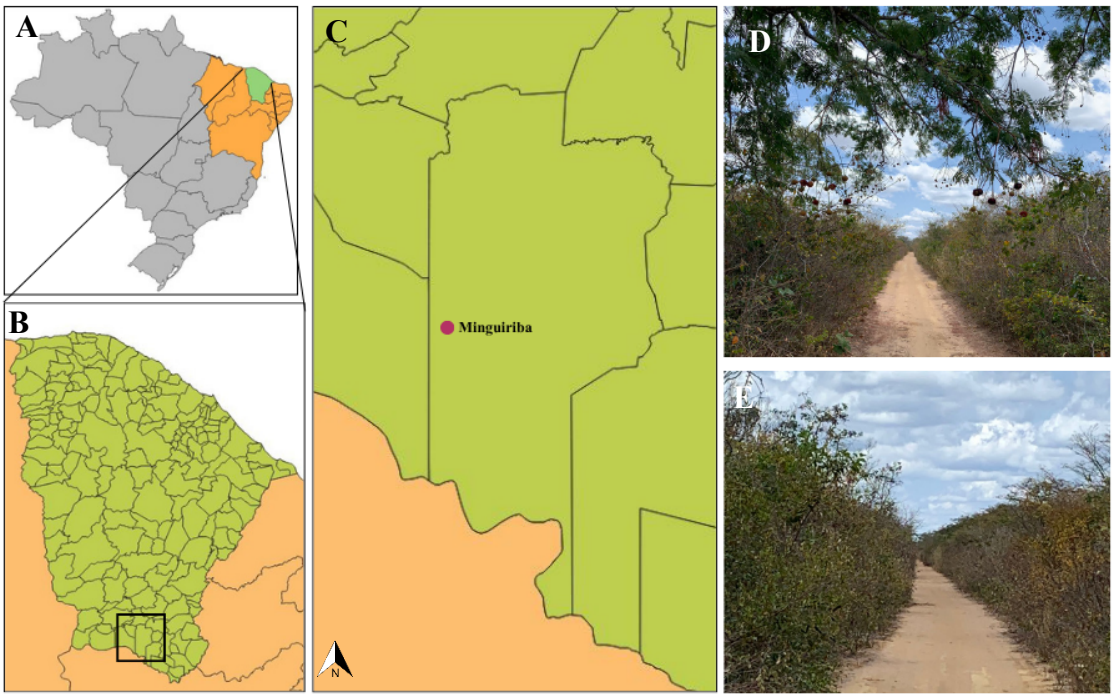

Figure 1. Collection site Minguiriba community located in the municipality of Crato, state of Ceará, Northeast region of Brazil. A – State of Ceará highlighted (green) in the Northeast region of Brazil. B – Municipality of Crato highlighted (square shape) in the southern region of the state. C – Location of the Minguiriba community where the samples were collected. D, E – Example of the sampling area and the type of vegetation found.

Collection and analysis

Two collection campains were carried out between May and September 2021, each lasting 15 days. The lizards were captured using interception and pitfall traps (100 30-liter buckets, distributed in 25 Y-shaped groups) and through active searches conducted during the day and night. After capture, that specimens were euthanized with a 2% lidocaine infection and necropsied in the laboratory, with their body cavities and respiratory and gastrointestinal organs individually analyzed under a stereomicroscope. The species were identified according to Vicente *et al.* (1993) and Anderson (2000). The prevalence, mean intensity of infection and mean abundance of parasites were calculated following (Bush *et al.,* 1997). Endoparasites and hosts were deposited in the Coleção Herpetológica da Universidade Federal do Cariri - CHERP – UFCA (CHERP-136, 241, 246, 247, 248, 540, 627, 671, 758, 811).

Ethical Approval and/or Informed Consent: The sampling of lizard specimens was authorized by the Chico Mendes Institute for Biodiversity Conservation (ICMBio), authorization n° 78313-1, and the Ethics Committee of the Regional University of Cariri (CEUA/URCA, case n° 001/2020).

RESULTS

In the present study, 10 species of lizards from five different families were sampled: Gekkonidae, Gymnophthalmidae, Iguanidae, Leiosauridae, Phyllodactylidae, Polychrotidae, Scincidae, Teiidae and Tropiduridae. Of the ten species of lizards captured, *Copeoglossum arajara* Rebouças-Spieker, 1981 (6), *Enyalius bibronii* Boulenger, 1885 (8)*, Hemidactylus brasilianus* (Amaral, 1935) (7)*, H. mabouia* (Morreau de Jonnès, 1818) (4)*, Iguana iguana* (Linnaeus, 1758) (3), *Micrablepharus maximiliani* (Reinhardt & Lutken, 1862) (5), *Polychrus acutirostris* Spix, 1825 (2)*, Phyllopezus pollycaris* (Spix, 1825) (5), *Salvator merianae* (Dumeril & Biberón, 1839) (2)*, Stenocercus squarrosus* Nogueira & Rodrigues, 2006 (3), five were infected.

Table 1. Parasites infecting lizard species found in the Carrasco, Ceará, Brazil. N = number of infected hosts, A = total abundance of parasites, MI = mean intensity of infection, P% = prevalence, Cav = cavity, St = stomach, SI, Li = large intestine.

Host	Parasite	Infection site	n	A	P [%]	MI
E. bibronii	*P. retusa*	St	2	2	20	2.8
	S. oscari	Li	2	34	50	8.5
	Onchocercidae larva	Cav	1	5	12.5	5
H. mabouia	*P. alvarengai*	Li	1	4	25	-
P. acutirostris	*G. bahiensis*	Li	1	45	50	-
P. pollicaris	*P. alvarengai*	Li	1	1	20	-
	P. travassosi	Li	1	56	20	-
	S. oxkutzcabiensis	Li	3	79	60	26.33
	Physaloptera sp.	St	1	4		-
S. merianae	*Diaphanocephalus* sp.	St	1	1	50	-
	P. retusa	St	1	12	50	2.8

The parasitic community consisted of nematodes *Diaphanocephalus* sp. Diesing 1851, *Gynaecometra bahiensis* Araujo 1978, *Parapharyngodon alvarengai* Freitas, 1957, *Pharyngodon travassosi* Pereira, 1935, *Physaloptera retusa* Rudolphi, 1819, *Spauligodon oxkutzcabiensis* (Chitwood, 1938), *Strongyluris oscari* Travassos, 1923, and Onhcocercidae (larva) (Table 1). The genera *Parapharyngodon* Chatterji, 1933 and *Physaloptera* Rudolphi, 1819 were the most common, found in four species, of the five species of lizards.

The lizard *P. pollicaris* (Spix, 1825) was the species with the highest parasitic diversity, harboring four of the eight nematode taxa recorded, and was a new host for *P. travassosi* Pereira, 1935. Also, *E. bibronii* Boulenger, 1885 is recorded as a new host for the Onchocercidae family. The species *H. mabouia* (Morreau de Jonnès, 1818) showed the lowest parasitic diversity, hosting a single species of nematode.

DISCUSSION

There are 93 know species of lizards from 13 different families in the Caatinga (Uchôa *et al.,* 2022), This study records parasitism information for individuals from five of these

families. Nematodes are still the main representatives of the endoparasite fauna associated with reptiles in the northeastern region of Brazil, with most being recorded as parasitizinf lizards (Lacerda *et al.*, 2023).

Two new host records were sampled among nematodes, for two species of lizards that are common in the Caatinga, *E. bibronii* Boulenger, 1885 and *P. pollicaris* (Spix, 1825) The genus *Enyalius* Wied, 1821 comprises nine species of lizards that exhibit arboreal habits, but can also be found on the ground. They are medium-sized and diurnal, being generalist predators that feed mainly on arthropods (Rodrigues *et al.,* 2006, Barreto-Lima & Sousa, 2011; Dorigo *et al*., 2014). In this study, nematodes of the genera *Physaloptera* Rudolphi, 1819, *Strongyluris* Müller, 1894 and Onchocercidae were recorded in the gastrointestinal tract of *E. bibronii* Boulenger, 1885.

The genus *Physaloptera* Rudolphi, 1819 is commonly associated with several species of lizards and can occur in high abundance in these hosts (Rocha *et al*., 2003; Bursey & Goldberg, 2004). *Strongyluris* Müller, 1894 on the other hand, is widely distributed throughout the world. (Bursey *et al*., 2003, Ávila *et al.,* 2012, Oda *et al.,* 2020), with records of occurrence for two species in Brazil, both in lizards (Kohn *et al.,* 1973, Dorigo *et al*., 2014). Both genera have previously been reported in *E. bibronii* Boulenger, 1885 and other species of lizards of the same genus (Vrcibradic *et al.,* 2007, 2008; Ávila & Silva, 2010; Dorigo *et al.*, 2014; Lacerda *et al.*, 2023). Of the species recorded in this study, *P. retusa* Rudolphi, 1819 has already been identified in 17 different species of lizards in the Northeast region (Lacerda *et al.,* 2023), and is associated with about 35 species of lizards in Brazil (Ávila *et al*., 2012, Araujo-Filho *et al.,* 2014; Lima *et al.,* 2017, Teixeira *et al.,* 2017; Teles *et al.,* 2017), while *S. oscari* Travassos, 1923 is commonly associated with lizards of the families Teiidae and Tropiduridae (Ávila *et al.*, 2012).

The Onchocercidae Chabaud & Anderson, 1959 family is represented by 88 genera of nematodes that can be found in blood or lymphatic vessels, the heart, lungs, body cavities, joints, and subcutaneous tissues (Moraes *et al*., 2022). Genera such as *Oswaldofilaria* Travassos, 1933, *Piratuba* Quaresma & Freitas, 1921, and *Piratuboides* Bain & Sulahian, 1974, mainly infect carnivorous reptiles (Ávila & Silva, 2010). Although there are records of parasitism by

onchocerids in lizards, such as Teiidae, Tropiduridae and Scincidae (Ávila & Silva, 2010; Lacerda *et al.*, 2023), the species *E. bibronii* Boulenger, 1885 had not previously been reported as infected by nematodes of this family and represents a new host for members of Onchocercidae.

Phyllopezus pollicaris (Spix, 1825) it is a lizard native to South America, widely distributed throughout the Northeast region of Brazil. Nocturnal in nature, it is considered an opportunistic forager, feeding on arthropods. It usually inhabits rocky outcrops, but can also be found near human dwellings (Vanzolini *et al.,* 1980, Vitt, 1995; Recorder *et al.*, 2012; Sousa *et al*., 2014). In this study, *P. pollicaris* (Spix, 1825) was the host species with the highest parasitic diversity, mainly hosting Pharyngodonidae nematodes. The previously known parasitic fauna associated with *P. pollicaris* (Spix, 1825) is small, represented by three species of nematodes, all Pharyngodonidae, and one species of pentastomid (Almeida *et al*., 2008, Ávila & Silva, 2010; Ávila *et al.,* 2012).

Pharyngodonidae Travassos, 1919 nematodes are extremely diverse, widely distributed, and parasitize various classes of vertebrates (Pereira *et al*., 2018). Of the genera recorded here, *Parapharyngodon* Chatterji, 1933 comprises 54 valid species, five of which can be found in amphibian and reptile hosts in the Caatinga (Ávila & Silva, 2010; Pereira *et al*., 2011; 2017, 2018; Araujo-Filho *et al*., 2015; Bursey & Goldberg, 2015; Ramalho *et al*., 2016; Rizvi et al., 2017; Santos *et al*., 2018, Ferreira *et al*., 2021) and, *P. alvarengai* Freitas, 1957 is the species most frequently reported in reptiles in northeastern Brazil, especially in the Caatinga (Araujo-Filho *et al*., 2015; Ferreira *et al*., 2021).

Spauligodon Skrjabin, Schikhobalova, Lagodovskaja, 1960 currently comprises 53 species reported in reptiles (Álvarez et al., 2021; Lacerda et al., 2023; Alvaro *et al*., 2024; Neves *et al*., 2025). In Brazil, there are records for the species *S. oxkutzcabiensis* (Chitwood, 1938) and *S. caxiuana* Neves, Silva, Santos, Tavares, González, Maschio & Melo, 2025, which are reported in lizards of the families Gekkonidae Oppel, 1811 and Phyllodactylidae Gamble, Bauer, Greenbaum & Jackman, 2008 (Sousa *et al*., 2014; Lima *et al*., 2017; Lacerda *et al*., 2023; Neves *et al.,* 2025). *Pharyngodon* Diesing, 1861 is commonly found in amphibians [94], but also in

reptiles, mainly lizards of the families Scincidae and Teiidae (Ávila & Silva, 2010; Lacerda *et al.,* 2023). *Phyllopezus pollicaris* (Spix, 1825) already had a record of association with another nematode of the genus, *P. cesarpintoi* Pereira, 1935 (Araujo-Filho et al. 2020), and represents a new host for the species *P. travassosi* Pereira, 1935.

Besides *P. pollicaris* (Spix, 1825) Pharyngodonidae spp. were found in the gastrointestinal tract of *H. mabouia* (Morreau de Jonnès, 1818). Phyllodactylidae Gamble, Bauer, Greenbaum & Jackman, 2008 and Gekkonidae Oppel, 1811 are two families of lizards from the Gekkota clade, phylogenetically related taxa (Sites *et al.,* 2011). Both occur in Brazil (Guedes *et al*., 2023) and inhabit the Caatinga (Vitt, 1995, Rocha *et al*., 2011; Andrade *et al.,* 2013). These species are sit-and-wait foragers, have nocturnal habits (with the exception of *L. klugei*, which has diurnal habits), and an insectivorous diet (Mesquita *et al*., 2006; Sousa, 2010; Albuquerque *et al.,* 2013; Passos, 2013, 2015)

Hemidactylus mabouia (Morreau de Jonnès, 1818) has a known association with several species of Pharyngodonidae (Lacerda *et al*., 2023). Here, the species was recorded only for *P. alvaregai* Freitas, 1957, being one of the two species with the lowest recorded parasitic diversity. However, it is worth noting that the helminth fauna associated with *H. mabouia* (Morreau de Jonnès, 1818) and other lizards of the genus includes not only nematodes, but also cestodes, pentastomids, acanthocephalans, and trematodes (Moravec *et al*., 1987; Rodrigues *et al*., 1990; Rodrigues, 1994, Bursey *et al*., 1997; Anjos *et al*., 2005, 2007).

The lizard *P. acutirostris* (Spix, 1825) occurs in the Caatinga (Uchôa *et al.,* 2022) and has a distribution that covers Argentina, Bolivia, and Brazil (Garda *et al*., 2012). It inhabits open areas and can be found near human dwellings (Vanzolini, 1974). It is diurnal and its diet consists of both arthropods and plant material (Vitt & Lacher, 1981). In this study, the specimens analyzed were parasitized only by *G. bahiensis* Araújo, 1976.

Polychrus acutirostris Spix, 1825 is known to be associated with only two species of nematodes, *P. retusa* Rudolphi, 1819 *and G. bahiensis* Araújo, 1976 (Ávila & Silva, 2010, Araujo-Filho *et al.,* 2014). The genus *Gynaecometra* Araujo, 1976 was proposed by (Araújo, 1976) to accommodate the only known species, *G. bahiensis* Araújo, 1976, described in a *P.*

acutirotris Spix, 1825 lizard in the state of Bahia. Until then, there were no known records of association of this parasite with other reptilian hosts. It has been found that this species of lizard has very little parasitic diversity. This may be due to factors such as the animal's metabolism, or its arboreal habits and diet, which may have important influences on the species of parasites that infect these lizards (Goater *et al.,* 1987, Araujo-Filho *et al*., 2014). Although other members of Oxyuridae have monoxenic life cycles (Anderson, 2000), the life cycle of *G. bahiensis* Araújo, 1976 is not well known, and the restricted association between *P. acutirotris* Spix, 1825 and *G. bahiensis* Araújo, 1976 lso needs further investigation.

Teiidae lizards are some of the most abundant in northeastern Brazil (Guedes *et al.,* 2023), and they also have the greatest richness and diversity of parasitic associations among reptiles in this group, together with members of the Tropiduridae family (Lacerda *et al.,* 2023). The lizard *S. merianae* (Dumeril & Bibron, 1839) is a species widely distributed in South America (Ávila-Pires, 1995). The species has an omnivorous diet consisting of arthropods (Kiefer & Sazima, 2002), small vertebrates, birds, rodents, amphibians, lizards, turtle eggs (Presch, 1973, Sazima & Haddad, 1992), and some fruits (Castro & Galetti, 2004, Colli, 2004, Kiefer & Sazima, 2002).

The helminth fauna associated with *S. merianae* (Dumeril & Biberón, 1839) is quite diverse, composed mainly of nematodes, but also with records of parasitism by cestodes (Lacerda *et al*., 2023). *Physaloptera* Rudolphi, 1819 is commonly found parasitizing this species of lizard, and a species of the genus has even been described in this host species (Pereira *et al*., 2012, 2014). The genus *Diaphanocephalus* Diesing, 1851 has only three species: *D. diesingi* (Freitas & Lente, 1938), *D. jacurunxi* (Alho, 1965) and *D. galeatus* (Rudolphi, 1819), occurring in Brazil and other regions of South America (Freitas & Lent, 1938; Araújo, 1976; Anderson, 2000; Teixeira et al., 2017; Quirino et al., 2018; Pereira *et al*., 2019). This is a little-known genus, with no record of nematodes from it in reptile groups other than lizards, and its species are commonly found only in teiid hosts (Lacerda *et al*., 2023), reflecting a type of restricted relationship that also requires further investigation.

Some authors claim that the carrasco originates from the partial destruction of the savanna, where the environment takes on the appearance of dense scrubland (Fernandes, 1990; Fernandes & Bezerra, 1990). Others report that the carrasco is an environment of vegetation formed by species from the savanna, caatinga, and forest, but also by species unique to it (Figueiredo, 1986), and thus could even be recognized as an environment separate from the caatinga (Andrade-Lima, 1978). However, there is no confirmation that the carrasco is vegetation different from the caatinga and the savanna, or a plagioclimate resulting from the degradation of the savanna, or even a type of fossil vegetation, representative of past environmental conditions (Araújo *et al*., 1998). Some differences in vegetation composition could be linked to factors such as soil composition, environmental variations, rainfall, and geographical proximity to other types of vegetation, with no consensus among authors on the phytogeographical conceptualization of the carrasco (Araújo *et al.,* 1999).

We found strong similarities in the composition and distribution of endoparasite species in the Carrasco and adjacent Caatinga environments. The natural history of these two environments may have similar origins, maintaining the similarity between their faunas. As Carrasco is part of the Caatinga, the data presented here provide new information, expanding knowledge about the composition of the helminthological fauna of lizards that occur in this phytophysiognomy. Considering its uniqueness, this study presents information on the nematode fauna for hosts in an environment that is still little known and explored.

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Resources: SCR

Software: GMCL, JAdeAF, FBP, SCR

Supervision: SCR, JAdeAF

Validation: GMCL, JAdeAF, FBP, SCR

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