

Helminths of the lizard *Colobosauroides cearensis* (Squamata, Gymnophthalmidae) in an area of Caatinga, Northeastern Brazil

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Abstract. Lizards are hosts to a variety of parasites, but in South America only 15% of lizard species have been studied for helminths. In the present study, the component community of helminths associated with the gymnophthalmid *Colobosauroides cearensis* in an area of Caatinga (7°22'46.08" S, 38°38'47.87" W) is reported. We examined 91 specimens from the Brazilian state of Ceará, and five taxa of helminths were recovered: four Nematoda (*Parapharyngodon largitor*, *Spauligodon* sp., *Physaloptera* sp. and *Oswaldocruzia* sp.) and one Cestoda (*Oochoristica* sp.). *Parapharyngodon largitor* was the most prevalent species (61%), and presented the highest mean abundance of infection (1.60 ± 0.18). Lizard body size influenced the richness and abundance of helminths, while infection parameters were not related to lizard sex.

Keywords. Parasites, nematodes, cestodes, neotropical.

Parasitological studies are necessary to understand host–parasite interactions and the role of parasite species within ecosystems (Bittencourt and Rocha, 2003; Hudson, 2005). Although the richness of parasites is greater than that of hosts, they are much less studied, which means a considerable portion of the biodiversity is unknown (Poulin and Morand, 2000; Rocha et al., 2016).

Lizards are host to a variety of parasites, including helminths (Anderson, 2000; Ávila and Silva, 2010; Ávila et al., 2011; 2012). Despite the recent increase in parasitological studies in lizards (Anjos et al., 2005; Ávila and Silva, 2010; Brito et al., 2014a; Bezerra et al., 2015), the knowledge of helminths remains scarce. For example, South America harbors more than 1120 lizard species (Uetz and Hosek, 2016), but only 15% of these species have had their associated helminths studied (Ávila and Silva, 2010).

The new world lizard family Gymnophthalmidae includes 235 species (Uetz and Hosek, 2016), and less

than 10% of these species have been studied regarding their parasitological aspects (Ávila and Silva, 2010). Information about parasitism in Gymnophthalmidae is punctual and usually appears in descriptions or records of new occurrences of parasites (Burse et al., 2005; Ávila et al., 2011; Albuquerque et al., 2012). In Brazil, data on the parasitic fauna of gymnophthalmids is concentrated in studies of the Amazon (Baker and Bain, 1981; Bursey et al., 2005; Albuquerque et al., 2012; Ávila and Silva, 2013), Cerrado (Ávila et al., 2011) and Restinga (Almeida et al., 2009). In the Caatinga domain, the knowledge related to helminth communities associated with gymnophthalmids remains little explored (Brito et al., 2014a).

Colobosauroides cearensis is a semifossorial and diurnal lizard with relictual distribution in the Caatinga. To the best of our knowledge, there are no records of helminths being associated with this lizard, mainly due to its fossorial habits (Cunha et al., 1991). Herein, we present data on the helminth community composition of the

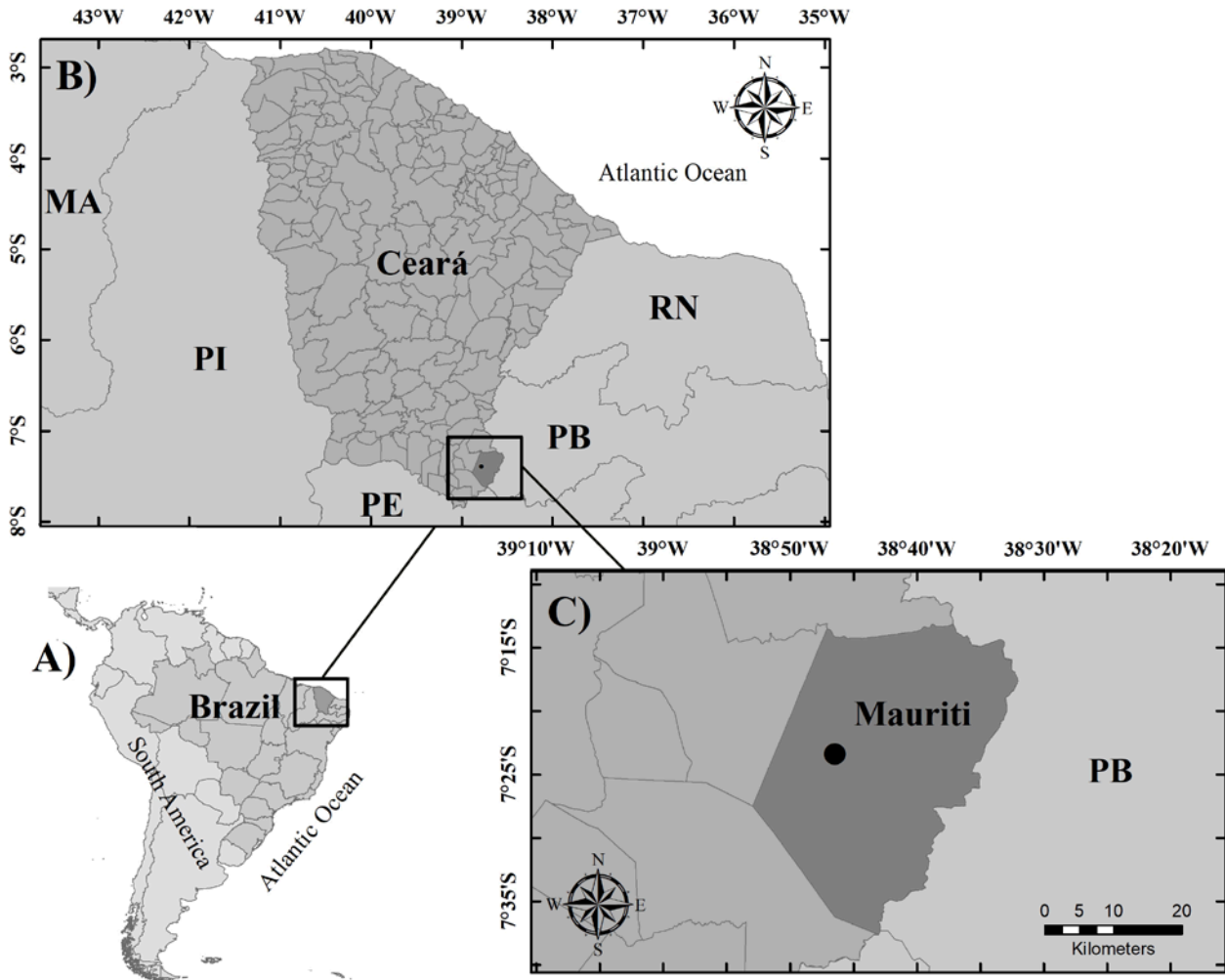


Fig. 1. Collecting site in State of Ceará (A) in Northeast Brazil; Mauriti municipality (B); Study area (C): São Miguel district.

lizard *Colobosauroides cearensis* in an area of Caatinga in the Northeast Region of Brazil.

We conducted this study in the municipality of Mauriti ($7^{\circ}22'46.08''\text{S}$, $38^{\circ}38'47.87''\text{W}$), state of Ceará, Northeastern Brazil (Fig. 1). The vegetation is characterized mainly by deciduous forest and hypoxerophytic Caatinga. The local climate is hot and semiarid, with the rainy period occurring from October to April, and the mean annual precipitation ranging from 500 to 800 mm (IPECE, 2015).

We captured 91 *Colobosauroides cearensis* (39 ± 7 mm SVL) by hand during three to five-day fieldtrips from December 2015 to December 2016; this comprised 47 adult females (39.9 ± 7.5 mm SVL), 36 adult males (42.8 ± 5.5 mm SVL) and 8 juveniles (22.0 ± 0.9 mm SVL). We euthanized the lizards with a lethal injection of sodium thiopental (CFMV, 2013); these were then fixed

in 10% formalin, preserved in 70% alcohol and deposited in the Herpetological Collection of the Regional University of Cariri (8451, 8452, 8453, 11453–11490; 11663–11687; 12399–12423). For each specimen, we measured the snout–vent length (SVL) with a digital caliper (± 0.01 mm) and mass to the nearest gram with a Pesola® spring scale (± 0.1 g).

We removed all organs of the respiratory and gastrointestinal tracts and examined them individually under a stereoscope for helminths. We transferred the collected helminths to 70% ethanol. We stained the cestodes with alcoholic hydrochloric acid-carmin, which were subsequently cleared in creosote, while nematodes were diaphanized in lactophenol. For each helminth species, the prevalence, mean abundance, and mean intensity of infection (following Bush et al., 1997) were estimated, where parasite mean abundance is defined as the arith-

Table 1. Mean abundance (MA), mean intensity of infection (MII) with range, prevalence (P) and site of infection of helminth community associated with the lizard *Colobosauroides cearensis* in the Caatinga, Northeastern Brazil. Values are mean \pm SE. SI: small intestine; ST: stomach; LI: large intestine.

Helminth	MA	MII	P	Site of infection
Cestoda				
<i>Oochoristica</i> sp.	0.05 \pm 0.03	1.6 \pm 0.7 (1-2)	3.3%	SI
Nematoda				
<i>Physaloptera</i> sp.	0.09 \pm 0.07	4.5 \pm 3.5 (2-7)	2.2%	ST
<i>Parapharyngodon largitor</i>	1.60 \pm 0.18	2.6 \pm 1.6 (1-10)	61.0%	SI, LI, ST
<i>Oswaldocruzia</i> sp.	0.02 \pm 0.02	2.0 \pm 2.0 (-)	1.1%	SI
<i>Spauligodon</i> sp.	0.06 \pm 0.04	2.0 \pm 1.0 (1-3)	4.4%	SI, LI

metic mean of the number of individuals of a particular parasite species per host examined; mean intensity of infection is the total number of parasites found in a sample, divided by the number of hosts infected with that parasite; and prevalence (P%) is the number of hosts infected with one or more individuals of a particular parasite species divided by the total host number. Throughout the text, results are reported as means \pm SE.

We used a generalized linear model with Poisson distribution (GLM) to analyze the relationship between abundance and helminth species richness with host body size and sex. We used a t-test to infer intersexual differences between SVL and mean helminth richness. All analyses were performed using the package Rcmdr in the R platform, version 2.15.0 (R Development Core Team, 2013).

We recovered 165 helminths with an overall prevalence of 69.2%. Mean overall abundance was 1.8 ± 0.2 and mean intensity of infection was 2.6 ± 1.6 . The component community of helminths associated with *Colobosauroides cearensis* comprised five taxa (Table 1): one cestode, *Oochoristica* sp., and four nematodes, *Parapharyngodon largitor*, *Spauligodon* sp., *Physaloptera* sp. and *Oswaldocruzia* sp.

Fifty-six individuals of *C. cearensis* (32 females and 24 males) were parasitized with *Parapharyngodon largitor* (61% prevalence), with this nematode also presenting the highest mean abundance (1.60 ± 0.18). *Oswaldocruzia* sp. were the least prevalent (1.1%) and the least abundant (0.02 ± 0.02).

The relationship between lizard SVL and the mean abundance of helminths was significant ($Z = 2.604$; $P = 0.009$). Although males (42.8 ± 5.5) were larger than females (39.9 ± 7.4 ; $t = 2.212$; $P = 0.029$), sex did not influence mean abundance ($Z = 0.935$; $P = 0.30$). The mean richness of helminths was low (0.736 ± 0.050), with no influence of host sex ($Z = -0.068$; $P = 0.60$), but the SVL influenced helminth mean richness ($Z = 2.282$; $P = 0.02$). Intersexual differences in mean richness were not

found, even when the effect of SVL was removed ($t = 0.267$; $df = 80.91$; $P = 0.70$). Moreover, no juvenile lizards were parasitized.

Our study provides the first parasitological record to the host *Colobosauroides cearensis*. Most taxa reported here were not identified to species level due to juvenile condition (*Physaloptera* sp.), bad conditions of preservation (*Oochoristica* sp. and *Oswaldocruzia* sp.) or because the present species probably represented an undescribed species (*Spauligodon* sp.). *Parapharyngodon largitor* is a generalist species, since it has been reported in several lizard species (Rodrigues, 1970; Vicente et al., 1993; Vrcibradic et al., 2002; Bittencourt and Rocha, 2003; Anjos et al., 2005; Ávila and Silva, 2010; Ávila et al., 2011).

Despite the higher prevalence, *P. largitor* presented low intensity of infection (2.6 ± 1.6), which is also noted for the genus *Parapharyngodon* in other lizard species: *Hemidactylus mabouia* (Squamata: Gekkonidae), *Phyllolopezus pollicaris* (Squamata: Phyllodactylidae), *Tropidurus itambere*, *T. torquatus*, *T. hispidus* (Squamata: Tropiduridae) (Rodrigues, 1987; Anjos et al., 2005; Pereira et al., 2011; Sousa et al., 2014; Araújo-Filho et al., 2016). Higher prevalence (61%) of *P. largitor* indicates success in colonization within host populations, which suggests that this species may be important in parasite community structure (Bush and Holmes, 1986; Holmes, 1987). Specimens of genus *Oswaldocruzia* sp. are frequently found infecting the intestines of amphibians and reptiles (Santos et al., 2008). *Oswaldocruzia* sp. has direct life cycle, transmission can occur through ingestion or larvae penetration in the skin (Anderson, 2000). *Oswaldocruzia* sp. was observed parasitizing several lizards from Brazil (Ávila and Silva, 2010), including *Tropidurus semitaeniatus*, *Brasiliscincus heathi* and *Anotosaura vanzolinia* in a Caatinga area (Brito et al., 2014a; Oliveira et al., 2017). The low prevalence and intensity of infection found here suggests accidental ingestion of eggs, which could occur through tongue-flicking behavior in substrate (Menezes et al., 2004).

The other helminth taxa found in the present study have been recorded in lizards from South America (Ávila et al., 2010), which have also been reported in other gymnophthalmids: *Oochoristica* sp. (*Apoglossus* sp., *Micrablepharus maximiliani*), *Physaloptera* sp. (*Cercosaura argulus*, *Bachia scolecoides*), *Spauligodon* sp. (*Micrablepharus maximiliani*) (Ávila et al., 2011; Brito et al., 2014a). The infection of other gymnophthalmids by the same taxa of parasites reported here may suggest phylogenetic relationships, since phylogenetically close taxa may present similarity in the use of a niche, body shape and behavior (Wiens and Graham, 2005; Lima et al., 2012; Brito et al., 2014a).

Host body size influences the establishment of populations and communities of parasites (Poulin, 2004; Kamiya et al., 2014a; 2014b). The individual's parasitic load (Poulin and George-Nascimento, 2007) is due in part to a larger 'area' of exploration and colonization provided by larger-sized specimens (MacArthur and Wilson, 1967; Aho, 1990). In addition, another relevant factor is that larger individuals are older and have therefore suffered longer exposure to parasitic agents (Aho, 1990). Studies of lizard populations have found a positive relationship between host body size and helminth infection rates (Barreto-Lima et al., 2011; Ávila and Silva, 2013; Araújo-Filho et al., 2014; Brito et al., 2014b).

There was no variation of richness and abundance between the sexes in *C. cearensis*, contrary to findings for other gymnophthalmids (Brito et al., 2014a). Intersexual variation in parasite loads may be related to hormonal, physiological and behavioral features; for example, larger males exhibit territorial behavior and frequently engaged in combat with other individuals, which may increase stress levels while decrease their immune response, thus becoming more susceptible to parasitic agents. In addition, testosterone production could be a powerful suppressor of immune system (Zuk and McKean, 1996). However, data regarding physiological and behavioral variation are lacking for *C. cearensis*. Moreover, other studies found no relationship between the parasitic rates and the sex of the lizards (Anjos et al., 2011; Bezerra et al., 2015).

Gymnophthalmids present low helminth richness, when compared to other lizards of the superfamily Teiioidea (Goldberg et al., 2013; Teixeira et al., 2016). Small body sizes in lizards of this family could restrict available niches to colonization and habitat segregation for endoparasites. Poor helminth richness compared to other lizard species in the same family was also reported in *Cercosaura argulus* (4 spp), *Cercosaura ocellata* (1 spp), *Leposoma osvaldoi* (1 spp), *Micrablepharus maximiliani* (3 spp) e *Anotosaura vanzolinia* (1 spp) (Ávila and Silva,

2010; Brito et al., 2014a; Oliveira et al., 2017). In the present study, we found the highest helminth richness within the lizard family Gymnophthalmidae, also providing new locality and host records.

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