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Helminths infecting the black false boa *Pseudoboa nigra* (Squamata: Dipsadidae) in northeastern Brazil

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Abstract. Knowledge about endoparasites of snakes is essential to understand the ecology of both parasites and hosts. Herein, we present information on helminths parasitizing the black false boa *Pseudoboa nigra* in northeastern Brazil. We examined 32 specimens from five Brazilian states (Ceará, Piauí, Pernambuco, Maranhão and Rio Grande do Norte). We found six helminths taxa: two acanthocephalans (*Acanthocephalus* sp. and *Oligacanthorhychus* sp.), three nematodes (*Hexametra boddaertii, Physaloptera* sp. and *Physalopteroides venancioi*), and one cestode (*Ophiotaenia* sp.). All parasites are reported for the first time infecting *P. nigra*, providing relevant information on infection patterns in this snake.

Keywords. Acanthocephala, Cestoda, Nematoda, Reptilia, snake.

Surveys of endoparasites associated with wild animals are key features to understand ecology, natural history, life cycles and evolution of parasites and their hosts (Silva, 2008). Parasites can influence their hosts in different ways, affecting their physiological and behavioural patterns (Levri, 1999), which can cause changes in coloration, and decrease in reproductive capacity, resulting in reduced reproductive success (Schall and Dearing, 1987; Dunlap and Schall, 1995).

Studies focusing on endoparasites in reptiles has grown in the past few years, and the diversity of parasites tends to increase as new hosts are studied (Ávila and Silva, 2010). In Brazilian snakes there is also an increase, especially in parasite species descriptions and new records of hosts (Bursey and Brooks, 2011; Norval et al., 2012; Pinto et al., 2012; Araújo-Filho et al., 2013; Ávila et al., 2013; Kuzmin et al., 2014, 2016; Mati et al., 2015). However, little is known about infection patterns in snakes from Brazil (Almeida et al., 2008).

The black false boa *Pseudoboa nigra* (Duméril, Bibron and Duméril, 1854) is widely distributed in Brazil, Bolivia, Paraguay and Argentina (Etchepare et al., 2015). Several aspects of its biology are known, such as diet and reproduction (Orofino et al., 2010; Gaiarsa et al., 2013; Mesquita et al., 2013). However, data on parasitism in this snake is restricted to the description of Protozoa *Trypanosoma serpentis* (Viola et al., 2009) and a report of the pentastomid *Raillietiella furcocerca* (Alcantara et al., 2014). Herein, we describe both the helminths richness and infection patterns (prevalence and intensity) in *P. nigra* from northeastern Brazil.

We examined 32 specimens of *P. nigra* from five Brazilian states in the northeastern region: Ceará (N = 20), Maranhão (N = 1), Piauí (N = 4), Pernambuco (N = 5)

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and Rio Grande do Norte (N = 2). We used specimens deposited at Coleção Herpetológica da Universidade Regional do Cariri (URCA-H 379, 507, 916, 2222, 2381, 3377, 3432, 3742, 3982, 4510, 4755, 4916, 5104, 5632, 5694, 5885, 5886, 7090, 8507, 9400, 9482, 9536, 10043, 10594, 10629, 11031, 11348, 11075, 11899, 11900, 12108, 12266), collected from 2011 to 2016.

We checked carefully for helminths, under a stereomicroscope, the gastrointestinal tract (esophagus, stomach, small and large intestines), liver, kidneys, lungs, gallbladder and coelomic cavity. For helminths identification, we stained acanthocephalans and cestodes with alcoholic hydrochloric acid-carmine and cleared in eugenol, while nematodes were diaphanized in lactic acid (Amato and Amato, 2010). After identification, all helminths species were deposited at Coleção Parasitológica da Universidade Regional do Cariri (URCA-P 476–521). We calculated parasitological parameters (prevalence, mean abundance and mean intensity of infection) according to Bush et al. (1997).

Of the black false boas analyzed, 23 specimens contained parasites, represented by six helminths species: two acanthocephalans (prevalence 59.3%) (*Acanthocephalus* sp., and *Oligacanthorhychus* sp.), three nematodes (43.75%) (*Hexametra boddaertii, Physaloptera* sp. and *Physalopteroides venancioi*), and one cestode (3.1%) (*Ophiotaenia* sp.). The overall prevalence was 71.9%, mean abundance 230.5 ± 126.5, mean intensity of infection 320.7 ± 173.4 (range: 1-3648) and richness 1.12 ± 0.15 in *P. nigra* (n = 32; SVL 579.8 ± 166.2) (Table 1).

P. nigra presented high helminth overall prevalence (71.9%), similarly to other snakes, such as in *Bothrops moojeni* (68%; Barrella and Silva, 2003), *Crotalus durissus terrificus* (66%; Dias et al., 2004), *Erythrolamprus miliaris* (44.4 %, 72.7%; Roldan and Fiorillo, 2016 and Mati et al., 2015, respectively). The richness and abundance of parasitic groups that contribute to high prevalence in these snake species vary according to the habits of their hosts. For example, Nematoda richness tends to be higher in terrestrial snakes, such as *P. nigra* (3 spp.; present study), *C. d. terrificus* (7 spp.; Dias et al., 2004) and *Crotalus mitchelli* (5 spp.; Goldberg et al., 2013), while Trematoda richness is higher in aquatic species, such as *E. miliaris* (17 spp.; Mati et al., 2015) and *N. natrix* (5 spp.; Yildirimhan, 2007). Thus, the richness, abundance and high prevalence of nematodes may be directly related to the host habitat (Brouat et al., 2007).

Acanthocephalans present indirect life cycle and use snakes as paratenic host (e.g., Travassos, 1917; Pizzatto and Madi, 2002; Pizzatto and Marques, 2006; Smales, 2007). *Oligacanthorhynchus* is represented actually by 34 species (Amin, 2013), two of these known to infect South American snakes: *Oligacanthorhynchus spira* infecting *Boa constrictor*, *Boiga dendrophila*, *Bothrops jararacussu*, *Bothrops neuwiedi*, *Clelia clelia*, *Erythrolamprus aesculapii*, *Erythrolamprus miliaris*, *Erythrolamprus poecilogyrus*, *Mastigodryas bifossatus*, *Micrurus corallinus*, *Philodryas olfersii*, *Xenodon merremii* and *Xenodon histricus* (Travassos, 1917; Pizzatto and Madi, 2002; Pizzatto and Marques, 2006); and *Oligacanthorhynchus taenioides* infecting *B. constrictor*, *B. dendrophila*, *B. jararacussu*, *B. neuwiedi*, *C. clelia*, *E. aesculapii*, *M. bifossatus*, *P. olfersii*, *X. merremii* and *X. histricus* (Travassos, 1917). Cystacanths of *Oligacanthorhynchus* sp. have also been reported in *Philodryas patagoniensis* (Smales, 2007).

Another acantocephalan found in the present study belongs to the genus *Acanthocephalus*. From the 54 known species (Amin, 2013; Amin et al., 2014), only *Acanthocephalus lutzi* has been reported infecting Brazilian snakes (*X. merremii* and *X. neuwiedii*; Smales, 2007).

Table 1. Helminths parasites associated with *Pseudoboa nigra* in five states from Northeastern Brazil. CE = Ceará; PE = Pernambuco; PI = Piauí; RN = Rio Grande do Norte, P = Prevalence; MA = Mean Abundance (± standard error); MII = Mean Intensity of Infection (± standard error); SI= Site of Infection; (Cc = Coelomic cavity, S = Stomach, Li = Large intestine, Si = Small intestine).

Helminths	States	P %	MA ± SE	MII ± SE	SI
Acanthocephala		62.5		377.74 ± 207.94	
Acanthocephalus sp.	CE, PE	6.25	2.5 ± 1.74	40.0 ± 3.0	S
Oligacanthorhychus sp.	CE, PE, PI	56.25	225.75 ± 126.5	401.33 ± 218.52	Cc, Si, Li
Nematoda		43.75		14.43 ± 9.51	
Hexametra boddaerti	CE, PE, PI	15.62	1.28 ± 0.69	8.20 ± 3.07	Cc, S, Si
Physaloptera sp.	CE, PE, RN,	31.25	4.83 ± 4.55	49.66 ± 47.02	Cc, S, Li
Physalopteroides venancioi	CE	3.13	0.03 ± 0.03	1.0	Si
Cestoda		3.13		4.0	
Ophiotaenia sp.	CE	3.13	0.12 ± 0.12	4.0	Si

In the present study, only cystacanths were found, suggesting that *P. nigra* acts as paratenic host for *Acanthocephalus*, with insects being the intermediate and birds the definitive hosts (Travassos, 1917; Schmidt and Roberts, 1996), thus suggesting that *Acanthocephalus* spp. may use *P. nigra* to reach its definitive hosts.

Identification of *Acanthocephalus* sp. and *Oligacanthorhynchus* sp. found in this study was not possible due to immature condition of specimens (cystacanths), making it difficult to analyze the proboscis hook formulas.

Nematodes were represented by *Hexametra boddaerti, Physaloptera* sp. and *Physalopteroides venancioi. H. boddaerti* is commonly found in lizards (Ávila and Silva, 2010) and snakes (Bursey and Brooks, 2011). The genus *Hexametra* contains 7 species (Baker, 1987), of which *H. boddaerti* is known to infect the following snakes in South American: *Bothrops* sp., *Crotalus durissus, Oxyrhopus trigeminus, Philodryas baroni,* and *Philodryas patagoniensis* (Skrjabin, 1916; Sprent, 1978; Hartdegen and Gamble, 2002; Pinto et al., 2010). Among the 105 *Physaloptera* species known (Pereira et al., 2014; Luiz et al., 2015) *P. monodens* infects *Boa constrictor*, *P. obitusissima* infects *Bothrops jararaca* (Skrjabin and Sobolev, 1964) and *Physaloptera* sp. infects *Micrurus surinamensis* (Ávila et al., 2013).

Physalopteroides venancioi is the only species with occurrence in the South America and is a generalist parasite of lizards (Ávila and Silva, 2010) and amphibians (Campião et al., 2014). However, this is the first record of *P. venancioi* infecting snakes. We suggest that infection of *P. nigra* by *P. venancioi* is accidental, being the parasite acquired from the feeding of the snake, since its diet consists mainly of lizards (Orofino et al., 2010).

In Brazil, there are five *Ophioteania* species infecting snakes: *Ophiotaenia calmetti, O. elongata, O. flava, O. hyalina*, and *O. macrobothria.* Only a few Brazilian snakes have been reported as host for *Ophiotaenia* species, among them, *Bothrops jararaca*, *Bothrops atrox*, *Corallus caninus* and *Micrurus corallinus* (Silva et al., 2006).

In conclusion, we found a high prevalence (71.9%) of helminths in the black false boa, reporting it as a new host for all helminth species here recorded, contributing to the increase of diversity and knowledge on parasites.

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