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First assessment of the endoparasitic nematode fauna of four psammophilous species of Tropiduridae (Squamata: Iguania) endemic to north-eastern Brazil

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Abstract. Tropiduridae (Squamata: Iguania) is a lizard taxon widely distributed in the neotropics. Among its representatives, some species are classified as generalists regarding habitat usage. Others exhibit a very restricted and probably relict distribution, and are strongly associated with predominantly sandy and dry habitats. Within this rather ecologically similar than phylogenetically closely related group we examined specimens of *Eurolophosaurus amathites*, *E. divaricatus*, *Tropidurus hygomi*, *T. psammonastes* for endoparasites. In all four species examined we recorded parasitic nematodes (Nemathelminthes: Nematoda). At least three nematode species were recovered: *Parapharyngodon* sp., *Physaloptera lutzi* and *Strongyluris oscari*, with *Ph. lutzi* being the most abundant parasite encountered in all lizard species examined. In spite of the hosts' habitat specialization, these parasites are also found frequently in non-psammophilous tropidurid species as well as in other squamates. Individual species richness per lizard was low, with usually just one species parasitizing at a time. These are the first parasites registered for these tropidurids and constitute a total of six new host records.

Keywords. Caatinga, psammophily, *Eurolophosaurus*, Nematoda, neotropics, *Tropidurus*.

Complete characterization of the ecological affinities of a species requires the analysis of a variety of aspects, ranging from physiological, through environmental to behavioral

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traits that are often interconnected. Among these various factors the parasites of a given species also constitute an important ecological data point (Poulin, 1999), as they can provide basic faunistic information about parasite-host relationships. However, especially in the case of neotropical squamates even such basic parasitological data are often lacking (Salgado-Maldonado et al., 2000).

Tropidurid lizards (Squamata: Tropiduridae) are found throughout most of South America and the vast majority were long lumped in the genus *Tropidurus* Wied-Neuwied, 1824 (Frost, 1992; Frost et al., 2001). Studies by Rodrigues (1988) revealed that the Brazilian distribution patterns of this former *Tropidurus*-complex, fall into four ecological (not phylogenetic) groups: (1) species with very wide-ranging distributions associated with open savanna-like formations, (2) species associated with small, isolated, forested regions, (3) species associated with mountain ranges, and (4) species with very limited or disjunct distributions, strongly associated with sandy soils.

Species that inhabit similar environments are likely to experience similar ecological phenomena, including host-parasite interactions. In the latter context we focus the present study

Fig. 1. Photographs of living representatives of the four tropidurid species examined (specimens not collected): *Eurolophosaurus amathites* at Gameleira de Assuruá, Gentio do Ouro (a), *E. divaricatus* at Ibiraba, Barra municipality (b), *Tropidurus hygomi* at Praia do Forte, Mata de São Joao municipality (c), *T. psammonastes* at Ibiraba, Barra municipality (d). All species are found in localities in the State of Bahia, Brazil. Photographs by A. Camacho (a,c) and M. Lambertz (b,d).

on endoparasites in four tropidurid species of the "sandy habitat" ecological group (Fig. 1). *Tropidurus hygomi* Reinhardt and Lütken, 1861 exhibits a disjunct distribution along a few coastal dunes in the states of Bahia and Sergipe (Fig. 2). Virtually nothing is known about the ecology of this microendemic species, and in particular, information about nutritional aspects are lacking. The fragmentary information regarding microhabitat usage, soils and ambient vegetation is summarized by Vanzolini and Gomes (1979) and Martins et al. (2010). The other three species studied here are endemic to a small dune field located on both sides of the middle portion of the São Francisco River in north-western Bahia (Fig. 2). These relict habitats within the Caatinga biome are populated by a large number of endemic lizards and snakes, and some general information is summarized by Rodrigues (1996) and Lambertz (2010). *Eurolophosaurus amathites* (Rodrigues, 1984) is geographically isolated from the remaining two species on the dunes at the eastern bank of the São Francisco River and

Fig. 2. Map of Bahia and Sergipe in northeastern Brazil showing the occurrence of the examined species of Tropiduridae. 1: *Eurolophosaurus amathites*, 2: *E. divaricatus*, 3: *Tropidurus hygomi*, 4: *T. psammonastes*. Two species, *E. divaricatus* and *T. psammonastes*, occur sympatric and are geographically isolated from *E. amathites* by the São Francisco River. One species, *T. hygomi*, occurs with a disjunct distribution close to the Atlantic coast in more than 500 km from the other populations. Distributional data after Rodrigues (1988).

also for this species there are virtually no ecological data available. *Eurolophosaurus divaricatus* (Rodrigues, 1986) and *T. psammonastes* Rodrigues, Kasahara and Yonenaga-Yassuda, 1988, on the other hand, sympatrically inhabit the dunes at the western bank of the São Francisco River. Rocha and Rodrigues (2005) compared microhabitat usage and diet of these two species and found that *T. psammonastes* shows a positive electivity for shaded and protected areas and mainly feeds on ants, while *E. divaricatus* shows a negative electivity for shaded and protected areas and feeds mainly on flowers.

Endoparasites have been reported for some representatives of Tropiduridae (Vicente et al., 1993; Fontes et al., 2003; Silva and Kohlsdorf, 2003; Bursey and Goldberg, 2004; Bursey et al., 2005; Pérez et al., 2007; Almeida et al., 2009; Bursey and Goldberg, 2009; Goldberg et al., 2009; Ávila and Silva, 2010; Ávila et al., 2010, 2011, 2012; Pereira et al., 2012). However, to date there is no report on any of the psammophilous species mentioned above and the data basis for lizards of the Caatinga biome in general is extremely poor (Ávila et al., 2012). The primary purpose of the present study is to contribute to the knowledge of the helminth fauna of north-eastern Brazil and to provide the first parasitological data especially for these relict tropidurids.

Twenty-four lizards (six adults of each species) from the *Coleção Herpetológica de Ribeirão Preto* (CHRP, Departamento de Biologia, FFCLRP, Universidade de São Paulo, Ribeirão Preto, São Paulo State, Brazil) were examined for endoparasites. All representatives were collected in locations in the state of Bahia, Brazil (*E. amathites*: October 2009, Cacimbas, 11°07'S, 42°44'W, CHRP 267, 269-273; *E. divaricatus*: June 2010, Ibiraba, 11º01'S, 43º08'W, CHRP 297, 300, 306, 314-316; *T. hygomi*: June 2002, Salvador, 12°55'S, 38°20'W, CHRP 473, 475, 476, 479-481; *T. psammonastes*: June 2010, Ibiraba, 11°01'S, 43º08'W, CHRP 320-325). Except for two *E. divaricatus*, all lizards examined were male. The specimens were originally collected for ecophysiological studies, after which they were killed by an overdosed intramuscular injection of ketamine and subsequently fixed according to standard procedures (e.g., Simmons, 2002) and maintained in 70% ethanol.

In the present study, snout-vent length (SVL) was measured with calipers (to the nearest 0.1 mm) (Table 1), the specimens were opened ventrally, and the coelomic cavity was examined for parasites both with the naked eye and using a dissecting microscope. The viscera were then removed, the gastrointestinal tract opened longitudinally and examined for parasites as described above. Parasites were removed, transferred to separate small, capped vials, labeled according to the location in which they were found (coelomic cavity, stomach, intestines), and stored in 70% ethanol. Nematodes were cleared with lactophenol and examined using the Leica Qwin Lite 3.1 computerized system. Voucher helminth specimens are deposited in the Coleção Helmintológica do Instituto de Biociências de Botucatu (CHIBB, Universidade Estadual Paulista, Botucatu, São Paulo State, Brazil). Five parameters regarding parasite infections studied here, individually for each lizard species, are (1) prevalence (ratio of hosts infected with a given parasite species in relation to total number of potential hosts examined), (2) mean intensity of infection (average number of each parasite species per infected host), (3) range of intensity (lowest and highest numbers of parasites encountered in infected hosts), (4) range of parasite abundance (lowest and highest numbers of parasites encountered in all potential hosts) and (5) mean parasite abundance (ratio of the total number of a given parasite in relation to total number of potential hosts examined). All parameters are defined according to Bush et al. (1997).

Table 1. Basic data on the lizards examined and parasitological data for the most frequently encountered species of parasite, *Physaloptera lutzi*, as well as the remaining nematodes.

Lizard hosts	n	SVL [mm]	*Physaloptera lutzi*						
			Prevalence [%]	Range of intensity of infection	Mean intensity of infection ± SD	Range of parasite abundance	Mean parasite abundance ± SD	Site(s) of infection	vouchers
Eurolophosaurus amathites	6	60.5-75	33.3	1-2	1.5 ± 0.71	0-2	0.5 ± 0.84	stomach	CHIBB 5071, 5073
Eurolophosaurus divaricatus	6	66.5-91.5	66.7	2-14	5.5 ± 5.74	0-14	3.67 ± 5.28	stomach	CHIBB 5074-5077
Tropidurus hygomi	6	60-69.9	100	1-6	2.67 ± 1.97	1-6	2.67 ± 1.97	stomach, coelomic cavity	CHIBB 5078-5081, 5083-5085
Tropidurus psammonastes	6	89.5-97.5	66.7	1-6	2.25 ± 2.5	0-6	1.5 ± 2.26	stomach, uppermost intestine	CHIBB 5086-5090
Other nematodes encountered									
Parapharyngodon sp. (in *E. amathites* only)			50	1-2	1.33 ± 0.58	0-2	0.67 ± 0.82	intestine	CHIBB 5069, 5070, 5072
Strongyluris oscari (in *T. hygomi* only)			16.67	2	2	0-2	0.33 ± 0.82	intestine (terminal region)	CHIBB 5082

Endoparasitic nematodes were observed in all four lizard species examined. In total, 56 nematodes belonging to at least three different species were found: *Parapharyngodon* sp. (Oxyuroidea: Pharyngodonidae), *Physaloptera lutzi* Cristofaro, 1976 (Spiruroidea: Physalopteridae) and *Strongyluris oscari* Travassos, 1923 (Oxyuroidea: Heterakidae). *Physaloptera lutzi* was found in specimens of all four lizard species examined. In *T. hygomi* it exhibited the highest prevalence (= 100 %) and in *E. divaricatus* exhibited the highest intensity of infection (= 14). The detailed results and voucher numbers for *Ph. lutzi* are summarized in Table 1. Further unidentifiable (larval) specimens belonging to *Parapharyngodon* Chatterji, 1933 were encountered in *E. amathites* only. *Strongyluris oscari* was found exclusively in one specimen of *T. hygomi*. Refer to Table 1 for details on these nematodes as well. Except for one specimen of *E. amathites*, which harbored *Parapharyngodon* sp. and *Ph. lutzi* simultaneously, all other lizards were infected by just one species of parasite at a time.

The present study suggests that the psammophilous tropidurids from the Brazilian dunes do indeed host similar species of endoparasitic nematodes, with *Ph. lutzi* as the most frequently encountered and most abundant species. Moreover, based on our data it appears that compared with other closely related lizards (e.g., Fontes et al., 2003; Ávila and Silva, 2010), the infestation per individual in all of the psammophilous species is limited to a small number of parasitic species at a time, usually one. Large sample sizes, as in the study of Fontes et al. (2003), were not possible for these rare tropidurids and consequently statistically supported generalizations on the population level cannot be made. Nevertheless, the present study resulted in a total of six new host records, and this general knowledge about parasite-host relationships is an important contribution to our better understanding the ecological affinities of these species. *Physaloptera lutzi* has been recorded for the first time parasitizing *E. amathites, E. divaricatus, T. hygomi* as well as *T. psammonastes*. *Strongyluris oscari* has been recorded for the first time parasitizing *T. hygomi*, and we recorded for the first time a representative of *Parapharyngodon* in *E. amathites*.

The nematode species reported here are frequently encountered parasitizing other tropidurid species as well as other squamates that do not inhabit extreme habitats, and appear to be widely distributed generalists. The evolutionary history of these host-parasite associations therefore could mirror the assumed relict distribution of these psammophilous lizards, and thus the initial infections could date back to phylogenetically earlier events with only very tolerant (mainly regarding temperature and aridity) parasitic elements still present. Nevertheless, studying the actual phylogenetic coupling of parasite-host interactions is a highly complex issue, which requires a special experimental design (e.g., Regenfuss, 1978). While the present study was not designed specifically to address this evolutionary topic, our findings may serve as a starting point for further such parasitological studies on tropidurid lizards. Especially the frequent infestation with *Ph. lutzi* could be useful in a molecular phylogeographic analysis that individually compares haplotypes of parasites and hosts. One good possibility for this application could be in the clarification of controversially discussed host phylogeny, such as in *Eurolophosaurus* (compare Rodrigues, 1986; Frost et al. 2001; Passoni et al., 2008).

The report on several gutted specimens of *T. hygomi* published by Vanzolini and Gomes (1979) in part was based on material they had received from unnamed helminthologists, but we were unable to find any reference to a parasitological study on this

species in spite of our intensive literature surveys. Thus, all of the parasite-host interactions described above are new host records. It is further relevant to point out that the one specimen of *Ph. lutzi* found in the coelomic cavity of a *T. hygomi* specimen is interpreted as an artifact, as this parasite is known to infect the gastrointestinal tract of a variety of lizards (e.g. Ávila and Silva, 2010). Furthermore, various species of *Physaloptera* Rudolphi, 1819 are known to attach themselves to the gastric mucosa of their host without feeding on it and remain within the digestive system (Anderson, 2000), but there is only limited information on species in reptiles, and apparently none on *Ph. lutzi*. We recorded specimens of this species actually piercing the wall of the digestive tract in other specimens of *T. hygomi*, where about one third of the nematode extended freely into the coelomic cavity while the rest remained within the organ. We therefore assume that this particular "coelomic" individual had successfully escaped from its natural habitat, most likely after the death of its host.

In conclusion, psammophilous lizards appear to share a similar, non-diverse assemblage of endoparasitic nematode species and the associated parasites are apparently limited to a few common generalists. Understanding how the hosts' evolutionary history couples with these parasites may further elucidate various aspects of the lizards' biology including their phylogenetic relationships.

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