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The nematode community in the Atlantic rainforest lizard *Enyalius perditus* Jackson, 1978 from south-eastern Brazil

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Abstract

Studies focusing on communities of helminths from Brazilian lizards are increasing, but there are many blanks in the knowledge of parasitic fauna of wild fauna. This lack of knowledge hampers understanding of ecological and parasitological aspects of involved species. Moreover, the majority of research has focused on parasitic fauna of lizards from families Tropiduridae and Scincidae. Only a few studies have looked at lizards from the family Leiosauridae, including some species of *Enyalius*. This study presents data on the gastrointestinal parasite fauna of *Enyalius perditus* and their relationships with ecological aspects of hosts in a disturbed Atlantic rainforest area in the state of Minas Gerais, south-eastern Brazil. Two nematode species, *Oswaldocruzia burseyi* [(Molineidae) and *Strongyluris oscari* (Heterakidae) were found. Nematode species showed an aggregated distribution in this host population, with *O. burseyi* being more aggregated than *S. oscari*. The present study extends the range of occurrence of *O. burseyi* to the Brazilian continental area.

Introduction

The host–parasite relationship is an important parameter in the study of animal communities, as such relationships affect population dynamics and community structure (Rocha *et al.*, 2000; Anjos *et al.*, 2005; Almeida *et al.*, 2009). The helminth fauna of lizards in South America has received greater attention in recent years, with many records of new hosts and localities as well as the description of new species (Goldberg *et al.*, 2004; Bursey *et al.*, 2005a, b; Durette-Desset *et al.*, 2006; Bursey & Goldberg, 2007; Vrcibradic *et al.*, 2008; Ávila & Silva, 2010). Nevertheless, studies on helminth communities and ecological aspects of host–parasite relationships remain scarce in the literature (Rocha & Vrcibradic, 2003; Anjos *et al.*, 2005) and greater knowledge on the parasitological and ecological features of different lizard species is needed.

The genus *Enyalius* Wied, 1821 is comprised of nine species (Sociedade Brasileira de Herpetologia, 2010) of diurnal, insectivorous lizards (Sousa & Cruz, 2008; Barreto-Lima, 2009) well distributed throughout different biomes in Brazil, such as the Atlantic rainforest (Etheridge, 1969; Vanzolini, 1972, 1974; Jackson, 1978), Amazon (Ávila-Pires, 1995; Vitt *et al.*, 1996), Caatinga (semi-arid brush) and Cerrado (savanna-like vegetation) (Bertolotto *et al.*, 2002; Rodrigues *et al.*, 2006). Despite the wide distribution of *Enyalius*, few studies have addressed its helminth fauna and parasite ecology (Vicente *et al.*, 1993; Durette-Desset *et al.*, 2006; Sousa *et al.*, 2007; Vrcibradic *et al.*, 2007, 2008). *Enyalius perditus*

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Jackson, 1978 is a small tropical lizard restricted to the easternmost Atlantic rainforest in southern and south-eastern Brazil (Jackson, 1978; Lima & Sousa, 2006) that has been insufficiently studied with regard to many ecological and behavioural aspects (Lima & Sousa, 2006).

As infection parameters, such as the prevalence and number of parasites, may be influenced by the sex, age, size (Ribas *et al.*, 1995) and diet composition (Goldberg *et al.*, 1993, 1995) of the host, the aim of the present study was to analyse helminth fauna from the gastrointestinal tract of *E. perditus* and determine the relationship between ecological aspects of the host, such as body mass, sex and size, and the parasitic fauna.

Materials and methods

Host and parasite sampling

Lizards were collected with pitfall traps in a forest fragment of the Santa Cândida Municipal Biological Reserve (21°45′35″S, 43°20′50″W) in the city of Juiz de Fora, state of Minas Gerais, Brazil, between 2002 and 2003. The lizard species were identified based on Rodrigues *et al.* (2006). Animals were weighed on a manual scale (accuracy: 0.10 g), euthanized with ether, fixed in a 10% formalin solution and stored in 70% ethanol. Snout–vent length (SVL), total body length (TBL) and tail length (TL) were measured with a caliper to the nearest 0.1 mm. Gonads were examined to determine the sex. The gastrointestinal tract (stomach, small and large intestines) was removed and examined for helminths under a stereomicroscope. Nematodes were removed, counted, treated with lactophenol for clarification and examined under an optical microscope (Leica® DM5000B), using the LAS software program (Leica Application Suite) for image analysis. The prevalence and mean intensity of infection of each nematode species were determined based on Bush *et al.* (1997).

Data analysis

Differences in body size and mean intensity of infection between sexes were determined using the Mann–Whitney test and Student's *t*-test, respectively. A test for proportions (*Z*-test) was used to determine whether there was a significant difference in overall prevalence between males and females (Zar, 1999). A Spearman rank correlation (Zar, 1999) was performed to evaluate the effect of host size (SVL) on the intensity of infection. A Spearman rank correlation was performed to evaluate the relationship between body mass and intensity of infection, using the residual values obtained from linear regression analysis between TL and body mass (Zar, 1999). The discrepancy index (*D*) was calculated, as suggested by Poulin (1993). This index has a minimum of zero ($D = 0$) when every host harbours the same number of parasites. When all parasites are found in a single host, aggregation is maximal ($D = 1$). This index was calculated using the Quantitative Parasitology 3.0 software program (Rózsa *et al.*, 2000). For all tests, the level of significance was $\alpha \leq 0.05$. Voucher specimens of the lizard hosts were deposited in the Herpetological Collection of the Zoology Laboratory of the Universidade Federal de Juiz de Fora (1–5s/n.2002/UFJF, 59–61.2002/UFJF, 233–240 CZ/UFJF, 243 CZ/UFJF, 245–255 CZ/UFJF, 257–275 CZ/UFJF) and parasite specimens were deposited in the Coleção Helmintológica do Instituto de Biociências de Botucatu (CHIBB Lotes nos 5099 and 6000).

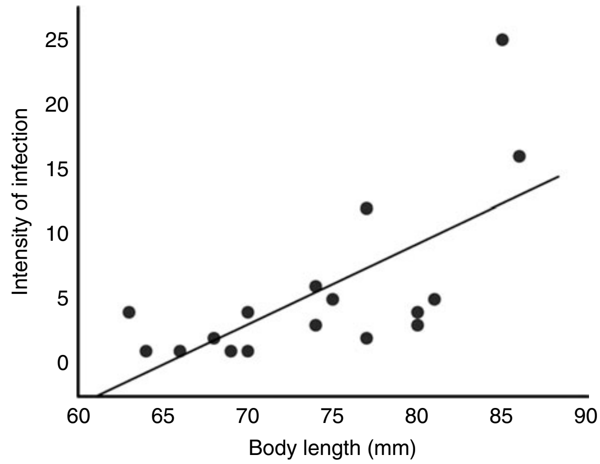

Fig. 1. Regression between body length and intensity of infection of *Enyalius perditus* from Reserva Biológica Municipal Fazenda Santa Cândida, Juiz de Fora municipality, Minas Gerais state, Brazil.

Results

Forty-nine specimens of *E. perditus* (31 males and 18 females) were examined: 27 adult males (SVL = 72.2 ± 5.2 mm; mass = 8.7 ± 2.2 g), 15 adult females (SVL = 83.8 ± 6.9 mm; mass = 15.9 ± 6.4 g) and seven juveniles (SVL = 37.4 ± 5.7 mm; mass = 1.5 ± 0.9 g). Size and body mass were different between adult males and

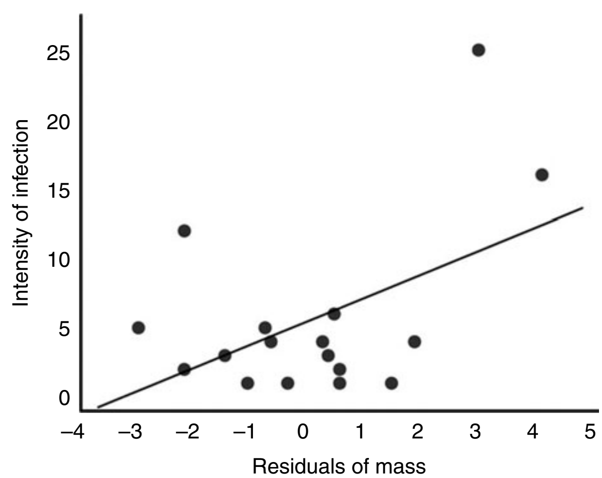

Fig. 2. Regression between mass (independent of total body length) and intensity of infection of *Enyalius perditus* from Reserva Biológica Municipal Fazenda Santa Cândida, Juiz de Fora municipality, Minas Gerais state, Brazil.

adult females (SVL: $Z(U) = 3.5$, $P < 0.001$; body mass = $Z(U) = 2.2$, $P < 0.05$).

The overall prevalence of parasites was 55.1% (27/49): 70.4% in adult males, 40.0% in adult females and 28.6% in juveniles. The difference between the prevalence of parasites in adult males and adult females was non-significant ($Z = 1.59$, $P = 0.11$). Mean intensity of infection was 7.1 ± 6.8 (range: 1–26). The mean intensity of infection was 11.3 ± 8.9 in adult females and 6.3 ± 6.0 in adult males. However, this difference did not achieve statistical significance ($t = 1.61$, df = 23, $P = 0.12$). Two juvenile lizards were infected by two and four nematodes. The body size (SVL) of adult lizards was positively associated with the intensity of infection ($F = 12.74$, $P = 0.003$, $r^2 = 0.423$) (fig. 1). After adjusting for the effect of total body length (residual between TBL × mass), body mass of the adult hosts was positively associated with the intensity of infection ($F = 4.68$; $P = 0.045$; $r^2 = 0.187$) (fig. 2).

Two nematode species were found in the stomach, small intestine and large intestine of lizards: *Oswaldocruzia burseyi* Duretter-Desset, Anjos & Vrcibradic, 2006 (Molineidae) and *Strongyluris oscari* Travassos, 1923 (Heterakidae). The prevalence of *O. burseyi* was 62.7% ($n = 17$), with a mean intensity of infection of 3.1 ± 2.9 (range 1–12) and discrepancy index of 0.621. The prevalence of *S. oscari* was 74.1% ($n = 20$), with a mean intensity of infection of 6.75 ± 6.4 (range 1–25) and discrepancy index of 0.572. The prevalence of these two nematode species was similar ($Z = 0.586$; $P = 0.558$). However, *S. oscari* exhibited a significantly higher mean intensity of infection ($t = -2.3$; $P = 0.03$). The discrepancy index (D) for both parasite species was 0.647 (*O.burseyi*, 0.621; *S. oscari*, 0.572).

Discussion

Lizards are hosts to a wide variety of gastrointestinal nematodes (Goldberg & Bursey, 1992). The cosmopolitan genus *Oswaldocruzia* Travassos, 1917 parasitizes amphibians (Durette-Desset *et al.*, 2006) and lizards from several families, such as Gekkonidae, Gymnphthalmidae, Iguanidae, Leiosauridae, Polychrotidae, Teiidae and Tropiduridae (Ávila & Silva, 2010). *Oswaldocruzia* nematodes are common parasites of lizards and new species have

Table 1. Helminth fauna of *Enyalius* spp. from Brazil; P(%), prevalence, MI, mean intensity of infection (± standard deviation).

	Enyalius bilineatus		*Enyalius iheringii*		*Enyalius perditus*		
Helminth species	P(%)	MI	P(%)	MI	P(%)	MI	Sites of infection
Acanthocephala							
Acanthocephalus sp.					7.1	3[1]	S, SI
Centrorhynchidae gen. sp.	3.7	2					S
Nematoda							
Acuariidae gen. sp. – larvae	25.9	1.7 ± 1.2					S, C
Cosmocercidade							
Aplectana vellardi					6	4.8 ± 0.5[2]	SI, LI
Cosmocerca sp.					14.3	4[1]	LI
Heterakidae							
Strongyluris oscari			16.7	6	28.6	1.5[1]	S, LI
					58	7.6 ± 7.3[2]	SI, LI
Molineidade							
Oswaldocruzia sp.[a]					–	–[3]	I
Oswaldocruzia fredi			33.3	5			S, SI
Oswaldocruzia burseyi					42.8	2.8[3]	S, SI, LI
Oswaldocruzia benslimanei	7.4	1.5					SI
Oswaldocruzia subauricularis					29	3.2 ± 3.1[2]	S, SI, LI
Physalopteridae							
Physaloptera lutzi	7.4	2					S, LI, LU, C
Physaloptera retusa	11.1	2.7 ± 0.6					S, LI, C
Rhabdiasidae							
Rhabdias sp.	33.3	2 ± 1.1	33.3	1	14.3	2[1]	LU
Locality (State)	Marechal Floriano (ES)		Ilha de São Sebastião (SP)		[1]Ilha de São Sebastião (SP) [2]Lima Duarte (MG) [3]Rio de Janeiro (RJ)		
References	Durette-Desset *et al.* (2006); Vrcibradic *et al.* (2007)		Vrcibradic *et al.* (2008)		Freitas (1955, 1956); Vicente *et al.* (1993); Durette-Desset *et al.* (2006); Sousa *et al.* (2007); Vrcibradic *et al.* (2008); Ávila & Silva (2010)		

Sites of infection: S, stomach, SI, small intestine; LI, large intestine; I, intestine; C, body cavity; LU, lungs.
Localities: ES, Espírito Santo State; MG, Minas Gerais; RJ, Rio de Janeiro State; SP, São Paulo State.
Rhabdias sp. was found in *E. catenatus* in the Ibateguara locality, Alagoas state, by Freire (2008): P(%) = 36.4, MI = 3.7(± 6.3).
[a] *Oswaldocruzia subauricularis* from the host *Enyalius catenatus* (without data), in Freitas (1955 and, probably, 1956) are both considered as *species inquirenda* by Durette-Desset *et al.* (2006), and *Enyalius catenatus* was described as *Enyalius perditus* by Jackson (1978).

been described infecting *Enyalius*, such as two new species of *Oswaldocruzia* sampled from the stomach and small intestine of *E. iheringii* and *E. perditus* on São Sebastião Island off the state of São Paulo, Brazil (Durette-Desset *et al.*, 2006) (table 1). Vrcibradic *et al.* (2008) reported that helminth assemblages in *E. perditus* and *E. iheringii* on São Sebastião Island were depauperate and dominated by generalist helminths with direct life cycles. It is important to note that the host species *E. catenatus* analysed by Freitas (1955) was later described as *E. perditus* by Jackson (1978) and its nematode species *O. subauricularis* was misidentified and is considered a *species inquirenda* by Durette-Desset *et al.* (2006).

Oswaldocruzia burseyi was initially recorded for an island habitat (São Sebastião Island) (Vrcibradic *et al.*, 2008) in an area of the Atlantic rainforest. The present study reports the first occurrence of *O. burseyi* in the state of Minas Gerais, extending its range of occurrence to the Brazilian mainland. The other species recorded in the present study, *S. oscari*, is a generalist parasite found in the stomach and intestine of different species of South American lizards: *Ameiva ameiva*, *Anolis fuscoauratus*, *A. punctatus*, *A. transversalis*, *E. iheringii*, *E. perditus*, *Eurolophosaurus nanuzae*, *Mabuya agilis*, *Plica plica*, *P. umbra*, *Stenocercus caducus*, *S. roseiventris*, *Tropidurus* sp. *T. guarani*, *T. spinulosus*, *T. torquatus* and *T. melanopleurus* (Sousa *et al.*, 2007; Vrcibradic *et al.*, 2008, Ávila & Silva, 2010).

The present study reports the lowest richness of helminth fauna associated with the gastrointestinal tract of species of *Enyalius*. Parasites and predators are the first groups to suffer from the environmental impact caused by human activities (Gibb & Hochuli, 2002; Laurence *et al.*, 2002). The Santa Cândida Municipal Biological Reserve, from which the lizards were sampled, is a small remnant of secondary Atlantic rainforest surrounded by human habitations. In the recent past, this area was covered by coffee plantations. According to McKenzie (2007), changes in anthropogenic land use affect the intermediate host fauna and, consequently, the helminth fauna. Thus, recent changes in the sampling area could have influenced the availability and abundance of prey, which may have reduced the richness of the helminth fauna in comparison to fauna in a typical natural forest (Vrcibradic *et al.*, 2008).

Results of the present study confirm the hypothesis that the intensity of infection increases with the body mass and size of the lizard host, which corroborates findings described in previous studies (Ribas *et al.*, 1995; Sousa *et al.*, 2007). The prevalence of parasites was higher in male lizards than in females. Similar findings are described for *Anolis* sp. (Vogel & Bundy, 1987), *Cnemidophorus ocellifer* (Ribas *et al.*, 1995) and *E. perditus* (Sousa *et al.*, 2007). However, a greater mean intensity of infection was found in females in the present study, which differs from findings reported for *E. perditus* by Sousa *et al.* (2007). This may be explained by local differences in the specific characteristics of the host populations in each study area and the small number of adult female hosts sampled in the present study. Lizards acquire nematodes through the ingestion of arthropods infected with the larvae of these parasites (Goldberg & Bursey, 1992; Ribas *et al.*, 1995). Thus, gender differences in the prevalence and intensity of helminths may be due to variations in body size and differences in prey consumption in qualitative and/or quantitative terms (Schoener, 1967; Fitch, 1981; Ribas *et al.*, 1995).

The habitat for parasites is not spatially continuous, but rather consists of cells or discrete 'islands', i.e. the hosts represent patches of favourable habitats in an uninhabitable environment. Parasites are also not evenly distributed among these islands. Some hosts contain more parasites than average, others contain less, and many individuals in the population may be free of parasites. Whichever the index of aggregation chosen, the result is usually the same; parasite populations are much more aggregated among their hosts than if the parasites were randomly distributed (Poulin, 1993, 1997). In the present study on the parasite biology of *E. perditus*, the nematode species exhibited a more aggregated distribution pattern in this host population and *O. burseyi* was more aggregated than individuals of *S. oscari*.

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