

Helminths of the exotic lizard *Hemidactylus mabouia* from a rock outcrop area in southeastern Brazil

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Abstract

The helminth fauna of 291 *Hemidactylus mabouia* (Lacertilia: Gekkonidae) from a rock outcrop area in the state of São Paulo, Southeastern Brazil, was studied. Five species were recovered, namely one unidentified species of centrorhynchid acanthocephalan (present only as cystacanths) and the nematodes *Parapharyngodon sceleratus*, *P. largitor* (Oxyuroidea: Pharingodonidae), *Physaloptera* sp. (Spiruroidea: Physalopteridae) and one indeterminate species of Acuariidae (Acuaroidae), with the latter two forms present only as larvae. Infection rates tended to increase with host size, but appeared to be unaffected by season. *Hemidactylus mabouia* shared most of its helminth fauna with two other sympatric lizard hosts, *Mabuya frenata* and *Tropidurus itambere*. The helminth assemblage of the *H. mabouia* population appears to have been entirely acquired by this exotic gecko from the local helminth species pool, rather than possessing any species from the parasite faunas of the original African populations.

Introduction

There have been few studies focusing on the helminth communities of exotic reptiles and amphibians in foreign habitats (Goldberg *et al.*, 1995; Hanley *et al.*, 1995; Barton, 1997; Goldberg & Bursey, 2000a; Criscione & Font, 2001). Parasites can be transported with their exotic hosts and become established in local populations of autochthonous species (Hanley *et al.*, 1995; Goldberg & Bursey, 2000a), whereas the introduced animals may rapidly acquire species of previously established parasites from the native fauna (Barton, 1997; Criscione & Font, 2001).

Hemidactylus mabouia (Squamata: Gekkonidae) is an exotic lizard species of African origin that is well-established and widely distributed in South America and the Lesser Antilles (Kluge, 1969; Avila-Pires, 1995). It has recently colonized the Florida Keys and southern mainland Florida, USA, where it appears to be rapidly expanding its distribution (Lawson *et al.*, 1991; Butterfield *et al.*, 1993; Meshaka *et al.*, 1994). The explanation for the

presence of this species in both Africa and tropical America has long been a controversial issue (see Avila-Pires, 1995), with some arguing in favour of its introduction from Africa into the neotropics via the slave trade and others advocating a much earlier invasion by natural rafting across the Atlantic Ocean (Levins & Heatwole, 1963; Kluge, 1969; Vanzolini, 1978). *Hemidactylus mabouia* is very common in Brazil, where it is usually associated with man-made structures and is frequently found in and around human dwellings, in both rural and urban areas (Vanzolini, 1978; Avila-Pires, 1995). It also occurs in relatively less disturbed habitats, and some information on its ecology in such habitats is available in the literature (Vitt, 1986, 1995; Araújo, 1991; Zamprogno & Teixeira, 1998; Rocha *et al.*, 2002). The helminth fauna associated with *H. mabouia* in the Old and the New World is varied and composed of several species of Nematoda, Cestoda, Trematoda, and Acanthocephala (Alho & Rodrigues, 1963; Simonsen & Sarda, 1985; Rodrigues, 1970, 1986, 1994; Moravec *et al.*, 1987; Rodrigues *et al.*, 1990; Bursey *et al.*, 1997; Goldberg & Bursey, 2000b). Nevertheless, there is little information about the characteristics and parameters (such as the helminth community structure, richness and diversity) of helminth

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assemblages associated with local populations of this invader species.

In the present study, the helminth fauna of a population of the exotic gecko *H. mabouia* in southeastern Brazil is analysed, with emphasis on community parameters, parasite–host relationships, and comparisons with the helminth fauna of two other sympatric lizard hosts.

Materials and methods

Fieldwork was carried out from April 2002 to March 2003 in a grassland area located within a farm (Fazenda Manga) in the municipality of Valinhos (22° 56'S; 46° 55'W; elevation *c.* 700 m), São Paulo State, southeastern Brazil. This area, which is mostly used for pasture, contains abundant granite boulders surrounded by grassy and shrubby vegetation (Van Sluys, 1993; Vrcibradic & Rocha, 1998). The rainy season in Valinhos extends from October to March and the dry season from April to September, with a mean annual temperature (\pm SD) of $20.7 \pm 2.2^\circ\text{C}$ and an annual rainfall of 1379 mm (Van Sluys *et al.*, 1994). During the period of this study, rainfall totalled 230 mm in the dry season and 1047 mm in the wet season (all climatic data were obtained from the Centro de Pesquisas em Agricultura (CEPAGRI) of the Universidade Estadual de Campinas).

A total of 291 lizards (87 adult males, 85 adult females and 119 juveniles) were collected with a noose or by hand. Immediately after capture, each lizard was transferred to a plastic bag containing cotton embedded in ether, in order to anaesthetize and euthanase them. In the laboratory, the snout-vent length (SVL) of each individual was measured with a caliper (to the nearest 0.01 mm) prior to fixation with 10% formalin solution and storage in 70% alcohol solution. Lizards were later dissected and their abdominal cavity and digestive tract (stomach and intestines) were examined for helminths.

A test for proportions (Z-test) was used to verify if there was a significant difference in overall prevalence between (i) males and females; (ii) adults and juveniles; (iii) hosts captured on wet and dry seasons; and (iv) lizards of different size classes. The software BioEstat 3.0 (Ayres *et al.*, 2003) was used to determine the range of each host size class and the number of hosts belonging to each class, so that the proportion of lizard hosts in each size class fitted a normal distribution curve.

Mann–Whitney tests were used to assess whether there were seasonal, inter-sexual or ontogenetic differences in infection intensities of the most frequently occurring parasite. A Spearman rank correlation (Zar, 1999) was performed to determine the effect of host size (SVL) on infection intensities. Spearman rank and Pearson correlations (Zar, 1999), respectively, were used to assess the effect of environmental mean temperature or rainfall on monthly infection intensities and prevalences of the more frequently occurring helminths. Data were converted to arcsine root square to fit a normal curve (Zar, 1999). As the infection parameters (such as monthly prevalence and intensity of infections) may not reflect an immediate response to monthly fluctuation in temperature or rainfall, further analyses were performed to consider time-lags of one and two months, respectively, and to

evaluate to what extent these environmental variables influence the infection parameters.

Previous studies focusing on the nematode fauna of two other sympatric (and syntopic) lizards, *Mabuya frenata* (Scincidae) (Vrcibradic *et al.*, 1999) and *Tropidurus itambere* (Iguanidae) (Van Sluys *et al.*, 1994) were taken as references for comparing helminth communities within the lizard host guild of the study site. Parasitological terminology used throughout follows that of Bush *et al.* (1997).

Results

There was no significant difference (Student-*t* test; $t = -0.231$; $P > 0.05$) in SVL between adult males (56.7 ± 5.0 mm; range = 46.9–68.2 mm; $n = 87$) and adult females (56.6 ± 5.2 mm; range = 47.9–67.2 mm; $n = 85$) of *H. mabouia*. The overall helminth prevalence was 46.4% (135/291). Five helminth species were found in *H. mabouia*, which consisted of one unidentified species of acanthocephalan (family Centrorhynchidae) and four species of nematodes: *Parapharyngodon sceleratus* Travassos, 1923, *P. largitor* Alho & Rodrigues, 1963 (Oxyuroidea: Pharyngodonidae), *Physaloptera* sp. (Spiruroidea: Physalopteridae) and an unidentified species of Acuariidae (Acuaroidea) (table 1). Of these, *Physaloptera* sp. and the acuariids were present only as larval stages and the acanthocephalans were present only as cystacanths. Some specimens of *Parapharyngodon* could not be credibly identified to species due to their parched condition or because they were broken, and thus were referred to as *Parapharyngodon* sp. (lizards in which these were found were excluded from calculations of mean helminth richness).

The mean helminth richness per infected host was 1.4 ± 0.6 (range 1–4; $n = 128$). The majority of infected lizards harboured only one helminth species (65.6%, $n = 84$), with a smaller percentage (29.7%, $n = 38$) harbouring two species, five lizards (3.9%) harbouring three species, and a single lizard (0.8%) harbouring four species (Centrorhynchidae, Acuariidae, *Physaloptera* sp. and *Parapharyngodon sceleratus*).

The highest overall helminth prevalence was recorded in October 2002 and the lowest in June 2002 (fig. 1). There was no significant difference in the overall prevalence between females (64.7%) and males (62.1%) ($Z = 0.20$; $P = 0.84$). Nevertheless, the prevalence was significantly higher in adult lizards (63.4%) than in juveniles (21.8%) ($Z = 6.68$; $P < 0.001$). There was no significant difference in overall prevalence between lizards collected in the dry (47.8%) and wet seasons (44.7%) ($Z = 0.41$; $P = 0.68$).

Five size classes for lizard hosts were established according to the statistic, and the overall helminth prevalence increased with host size (table 2). Prevalence values did not differ between the larger size classes (i.e. in the ranges 50.2–59.2 mm and 59.3–68.2 mm), but the prevalences in these size classes were higher than in the smaller hosts in the lower size classes (table 2).

With reference to the intensity of infection of the most frequently occurring helminth (i.e. the acanthocephalan), adult females presented the highest values (6.1 ± 10.3 ; $n = 38$), followed by adult males (3.6 ± 3.4 ; $n = 42$) and juveniles (2.2 ± 1.4 ; $n = 18$). The mean infection intensity was significantly higher in adults than in juveniles

Table 1. Prevalence (P, in %), infection intensity (mean \pm 1 standard deviation and range) and infection sites for each helminth species associated with *Hemidactylus mabouia* and two other sympatric lizards (*Mabuya frenata* and *Tropidurus itambere*) from a rock outcrop area in Valinhos, Brazil.

Host species	Helminth species	P (%)	Mean intensity (range)	Infection sites
<i>Hemidactylus mabouia</i>	Centrorhynchidae (cystacanths)	33.7	4.2 \pm 7.0 (1–61)	SW, IW, M
	<i>Parapharyngodon sceleratus</i>	14.1	1.8 \pm 1.5 (1–9)	PI, AI
	Acuariidae indet. (larvae)	8.2	3.4 \pm 3.2 (1–12)	SW
	<i>Physaloptera</i> sp. (larvae)	4.5	6.5 \pm 12.1 (1–40)	S
<i>Mabuya frenata</i> ¹	<i>Parapharyngodon largitor</i>	1.0	1.3 \pm 0.6 (1–2)	PI
	<i>Parapharyngodon sceleratus</i>	48.7	2.6 \pm 1.9 (1–13)	PI, AI, BC
	<i>Skrjabinodon heliocostai</i>	4.7	9.4 \pm 11.4 (1–32)	PI, AI
	<i>Hexametra boddaertii</i> (larvae)	1.7	2.3 \pm 1.0 (1–3)	BC, AI
	<i>Oswaldofilaria</i> sp.	0.4	1	BC
	<i>Oochoristica</i> sp.	0.4	1	AI
<i>Tropidurus itambere</i> ²	<i>Parapharyngodon sceleratus</i>	79	4.2	PI
	<i>Physaloptera lutzi</i>	27	3.1	S, AI

Source: ¹Vrcibradic *et al.*, 1999; ²Van Sluys *et al.*, 1994.

AI, anterior intestine; BC, body cavity; IW, intestine wall; M, mesentery; PI, posterior intestine; S, stomach; SW, stomach wall.

(Mann–Whitney; $U = 491.5$; $P < 0.05$) and, within adults, also significantly higher in females compared with males (Mann–Whitney; $U = 583.5$; $P < 0.05$). There was no significant difference between the mean intensity of the acanthocephalan during the dry season (3.6 ± 2.8) and the wet season (5.1 ± 9.7) (Mann–Whitney, $U = 1176.5$; $P = 0.89$). Host body size did not influence the mean infection intensity of the acanthocephalan in adult males ($r_s = 0.032$; $P = 0.84$; $n = 42$), adult females ($r_s = 0.128$; $P = 0.44$; $n = 38$) or juveniles ($r_s = 0.176$; $P = 0.48$; $n = 18$).

Monthly mean temperature and rainfall neither influenced prevalence nor intensity of infection by the acanthocephalan, even using one and two month time lags (table 3). There was, however, a significant negative relationship between temperature and infection intensity with a two-month time-lag (table 3), but the P -value

(0.045) was very close to the significance value (0.05), so that there is a risk of incurring a type II error.

Discussion

The population of *Hemidactylus mabouia* had a relatively high prevalence of helminth infection (46%), similar to that reported by Vrcibradic *et al.* (1999) for the sympatric skink *Mabuya frenata* (55%), but lower than that reported by Van Sluys *et al.* (1994) for the also sympatric iguanian *Tropidurus itambere* (81%). Nevertheless, the values for the latter two species should be considered underestimates, as they represent only infections by nematodes. Thus, *H. mabouia* tends to be less frequently parasitized than the other two common lizards in the area. This may be related to the gecko's lower mobility and smaller food intake (L.A. Anjos, unpublished data), which would result in a reduced exposure to potential intermediate hosts (Aho, 1990). However, the helminth fauna of *H. mabouia* is comparable in richness (five species) to that of the sympatric *M. frenata* (table 1). A survey of the helminths associated with *H. mabouia* in an urban environment (Rio de Janeiro city, Southeastern Brazil) revealed a relatively diverse assemblage composed by eight species belonging to four groups (Nematoda, Trematoda, Cestoda and Acanthocephala) (Rodrigues, 1970). In another study, Simonsen & Sarda (1985) recorded nine helminth species comprising nematodes, trematodes, cestodes and acanthocephalans, plus one species of Pentastomida, in another synanthropic population of *H. mabouia* from Tanzania. In both of these studies (Rodrigues, 1970; Simonsen & Sarda, 1985), the overall prevalence of infection was higher than 75%, suggesting that the infection rates and species richness of the helminth assemblages of *H. mabouia* are higher in populations from urban environments.

Hemidactylus mabouia represents a new host for the genus *Physaloptera*. Rodrigues (1970) recorded larval Physalopterinae in *H. mabouia* from Rio de Janeiro, Brazil,

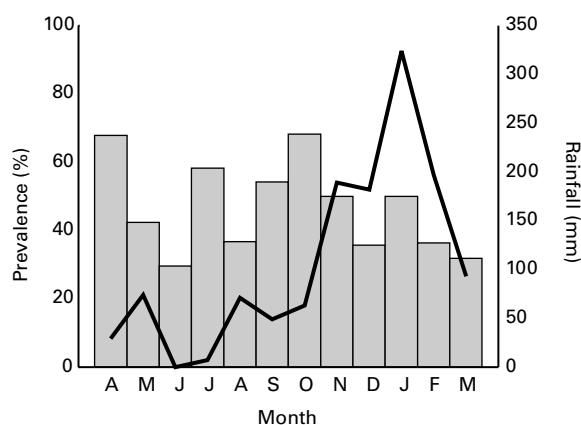


Fig. 1. Monthly prevalence (grey bars) of helminths in *Hemidactylus mabouia* and monthly rainfall (mm) in the study area (black line) during the period from April 2002 to March 2003 in Valinhos, Brazil

Table 2. Overall helminth prevalence (absolute number and percentage) for each size class (represented by SVL, in mm) of *Hemidactylus mabouia* from Valinhos, Brazil.

Host size class (mm)	Overall prevalence (%)	Z-test results		
		Host size class	Z	P
A (23.0–32.0)	5/34 (14.7)	B–C	2.06	< 0.05
B (32.1–41.1)	10/50 (20.0)	B–D	4.46	< 0.001
C (41.2–50.1)	23/57 (40.4)	B–E	5.05	< 0.001
D (50.2–59.2)	52/85 (61.2)	C–D	2.26	< 0.05
E (59.3–68.2)	45/65 (69.2)	C–E	3.02	< 0.05
		D–E	0.85	0.395

though the worms were not identified to genus. Larval *Physaloptera* sp. have also been recorded in another congener, *Hemidactylus frenatus*, from Oceania (Goldberg & Bursey, 2002). It is probable that *Physaloptera* spp. may not be able to mature in lizards of the genus *Hemidactylus*, and this is also suggested by the fact that adult *Physaloptera lutzi* has been recorded infecting the sympatric lizard *Tropidurus itambere* in our study area (Van Sluys *et al.*, 1994). Acuarian larvae have previously been reported from one North American population of *Hemidactylus turcicus* (Criscione & Font 2001), and are here reported for the first time in *Hemidactylus mabouia*. Centrorhynchid acanthocephalans (cystacanths) and the two *Parapharyngodon* species have all been previously recorded in other *Hemidactylus mabouia* populations from Rio de Janeiro State, Brazil (Alho & Rodrigues, 1963; Rodrigues, 1970, 1986).

Hemidactylus mabouia does not represent the final host for some of the helminth species it harbours in Valinhos, namely the physalopterans, acuarian and acanthocephalans. The gecko may serve as an intermediate/paratenic host for at least the last two, which are likely to have birds as their final hosts (Petrochenko, 1958; Dobson *et al.*, 1992; Anderson, 2000). Helminth species that do not use lizards as final hosts apparently represent a frequent (and often important) component of lizard helminth communities (Sharpilo *et al.*, 2001; Vrcibradic *et al.*, 2002).

The overall infection rates of the commonest parasite taxon (Centrorhynchidae) in *H. mabouia* were neither

significantly influenced by monthly rainfall nor by monthly mean temperature, in spite of its climatic seasonality. Vrcibradic *et al.* (1999) also found no correlation between rainfall and the prevalence of *P. sceleratus* in *Mabuya frenata* in the same area, commenting that seasonal fluctuations in arthropod availability may not influence the infection patterns of this monoxenic parasite. The availability of potential prey for lizards (i.e. small arthropods) did not vary significantly throughout the period of our study (L.A. Anjos, unpublished data), so that the availability of intermediate hosts for heteroxenous parasites such as acanthocephalans also remained relatively constant. Likewise, the similarity in body size, diet composition and microhabitat use between male and female *H. mabouia* (L.A. Anjos, unpublished data) probably accounted for the lack of differences in helminth prevalences between sexes (though females were, for some reason, more heavily parasitized than males).

The results of the present study allow some comparisons to be made with data from two other studies (Van Sluys *et al.*, 1994; Vrcibradic *et al.*, 1999) dealing with the nematode fauna of two lizards (*Mabuya frenata* and *Tropidurus itambere*) living sympatrically and syntopically with *H. mabouia* in the study area. *Parapharyngodon sceleratus* was the only (and also the most prevalent) nematode species recorded in the three lizard species. As suggested by Vrcibradic *et al.* (1999), *P. sceleratus* is probably a core species in the helminth community

Table 3. Results of correlations between climatic variables (monthly mean temperature and monthly rainfall) and the infection parameters (prevalence and mean infection intensity) of acanthocephalan cystacanths (Centrorhynchidae) infecting *Hemidactylus mabouia* in Valinhos, Brazil, from April 2002 to March 2003.

	Spearman rank correlation						Pearson correlation					
	Monthly mean temperature × intensity			Monthly rainfall × intensity			Monthly mean temperature × prevalence			Monthly rainfall × prevalence		
	r_s	P	n	r_s	P	n	r_p	P	n	r_p	P	n
Without time lag	0.098	0.762	12	0.140	0.665	12	0.270	0.396	12	0.064	0.844	12
1 month time lag	−0.210	0.513	12	−0.315	0.32	12	0.421	0.173	12	−0.047	0.884	12
2 months time lag	−0.587	0.045	12	−0.552	0.062	12	−0.204	0.524	12	0.054	0.869	12

^a Results are expressed as Spearman rank correlation coefficient (r_s) and Pearson coefficient (r_p), P-value (P) and number of sampled months (n).

associated with the lizard guild of Valinhos. Unfortunately, more appropriate comparisons between the local helminth fauna of the three lizards cannot be made, since samples were collected during different years and the studies of Van Sluys *et al.* (1994) and Vrcibradic *et al.* (1999) focused only on nematodes. Furthermore, acuariids and acanthocephalans probably went undetected during the two aforementioned studies, due to their small size and to the fact that they usually occur encysted on the stomach wall. An examination of the stomachs of three specimens of *M. frenata* collected from the same area during September 1997 revealed the presence of acuariid larvae in two and acanthocephalan cystacanths in all of them (D. Vrcibradic, unpublished data). This therefore suggests that the helminth faunas of the three lizards may be more similar than is apparent from the present data. The feeding habits, mobility and physiology of a given host and its contact with monoxenic parasites constitute important factors influencing composition, richness and structure of helminth communities (e.g. Aho, 1990). In Valinhos, all three lizard host species whose associated helminth faunas were studied share the same preferred microhabitat (granite boulders), and their diets consist almost exclusively of arthropods (mainly insects) (Van Sluys, 1993; Vrcibradic & Rocha, 1998; L.A. Anjos, unpublished data). Nevertheless, intrinsic factors, such as the particular ecological and physiological features of each lizard species (which are distantly related to each other), may determine the differences observed in the composition and structure of their helminth faunas.

The helminth assemblage associated with *H. mabouia* in Valinhos was composed of taxa that, with the exception of *P. largitor*, are common in various Brazilian lizard species (e.g. Vicente *et al.*, 1993; Vrcibradic *et al.*, 2000, 2002; Rocha & Vrcibradic, 2003), including two that co-occur with the gecko in Valinhos (see above). The two parasites that could be identified to species (*P. scleratus* and *P. largitor*) are both Neotropical forms (see Bursey & Goldberg, 1999). Thus, the helminth fauna of this gecko in the study area seems to be a typically Neotropical one, acquired mainly from the local pool of helminth species, with no evidence of helminth species that could have been brought with the gecko from its original African range. Barton (1997) mentions that the acquisition of native parasites by an exotic host is more likely to occur than its parasites being introduced to the native fauna. According to a survey of the endoparasites of the exotic toad *Bufo marinus* in Australia (Barton, 1997), its helminth fauna has been entirely acquired from native Australian host species, though the helminth faunas of other exotic populations in the Caribbean are apparently composed mainly of species from the toad's native mainland South-Central American range. Similar data are available for hemidactylid geckos in exotic localities. Criscione & Font (2001) found the helminth fauna of *Hemidactylus turcicus* in southeastern Louisiana, USA, to have been almost entirely acquired from local native amphibian and reptile hosts. Data from Hanley *et al.* (1995), on the other hand, show that *H. frenatus* has kept much of its original helminth fauna as it colonized the South Pacific islands, while at the same time acquiring some parasites from the resident gecko *Lepidodactylus lugubris*. The colonization of the neotropics by *Hemidactylus mabouia*, which has either

been 'naturally' introduced from Africa several thousand years ago or accidentally introduced by man with the slave trade prior to the 19th century, has occurred much earlier than the human-caused introductions of the two aforementioned congeners. Thus, it is not surprising that helminth communities associated with this gecko in Valinhos and other Brazilian localities (Rodrigues, 1970, 1986) are exclusively composed of local forms, especially if the usual host-generalist character of the helminths of reptiles and amphibians is considered. Thus, the geckos may have rapidly acquired helminths from the local faunas as they colonized continental South America and the Antilles following their arrival from Africa.

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