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Helminth communities of two sympatric skinks (*Mabuya agilis* and *Mabuya macrorhyncha*) from two 'restinga' habitats in southeastern Brazil

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Abstract

The helminth fauna of two sympatric congeneric skinks (*Mabuya agilis* and *M. macrorhyncha*) from two distinct 'restinga' habitats (Praia das Neves and Grussaí) in southeastern Brazil were studied, totalling four data sets (sample sizes ranging from 11 to 28). A total of ten helminth species were associated with the skinks: *Raillietiella* sp., *Paradistomum parvissimum*, *Pulchrosomoides elegans*, *Oochoristica ameivae*, *Hexametra boddaertii*, *Parapharyngodon sceleratus*, *Physalopteroides venancioi*, *Physaloptera* sp., an unidentified acuariid nematode and an unidentified centrorhynchid acanthocephalan. Except for *Hexametra boddaertii* (found only in Grussaí) and *Pulchrosomoides elegans* (found only in Praia das Neves), all helminth species were present at both localities. Half of the helminth species were present only as larvae and, in most cases, appear to represent paratenic parasitism. Overall prevalences of infection were high for both host species in both localities. *Mabuya agilis* tended to have richer and more diverse infracommunities than *M. macrorhyncha*. Some parameters of infection by individual helminth species seem to be related to the ecology of each *Mabuya* species. The parasite faunas were qualitatively very similar among species and/or localities, but quantitative similarities were more varied, due to differential representativeness of individual helminth species among host populations. The helminth communities of both skink species can be classified as non-interactive, being composed of site-specialists and immature stages of non-lizard parasites.

Introduction

Although ecological studies involving helminth communities of amphibians and reptiles have increased in recent years, there is still a paucity of comparative studies on closely related hosts occurring sympatrically or on different populations of a given host species (Aho, 1990; Janovy *et al.*, 1992). Regarding lizards, a few such studies have recently been published (Bundy *et al.*, 1987; Dobson & Pacala, 1992; Dobson *et al.*, 1992; Biserkov & Kostadinova, 1998; Sharpilo *et al.*, 2001), but information is sorely lacking for taxa from the southern hemisphere, including tropical America.

The neotropical skinks *Mabuya agilis* (Raddi, 1823) and *Mabuya macrorhyncha* Hoge, 1946 are common along coastal areas of eastern Brazil, where they usually occur in

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sympatry (e.g. Araújo, 1994; Rocha, 1998, 2000). The former species is mainly terrestrial, whereas the latter is more scansorial, being commonly found associated with ground bromeliads (Vrcibradic & Rocha, 1996). The helminth fauna infecting these two species has recently been studied in a few localities along the Brazilian coast (Van Sluys *et al.*, 1997; Ribas *et al.*, 1998; Vrcibradic *et al.* 2000a, 2001, 2002). However, most of these studies deal only with nematodes. In the present paper, the helminth communities (and their parameters) of populations of *M. agilis* and *M. macrorhyncha* from each of two localities in coastal Brazil are studied and the results compared among species and among localities. The main questions are: (i) which helminth species are infecting each host species at each locality, and at what frequencies and intensities? (ii) does the richness and diversity of infracommunities differ more between host species or between localities? and (iii) are component communities more similar between host species within each locality or between different populations of the same host species?

Field samples used in this work can be considered as relatively homogeneous, having all been collected within a relatively short time period (see Janovy & Kutish, 1988).

Materials and methods

Specimens of *M. macrorhyncha* and *M. agilis* were collected during November and December 1999 from two coastal localities in southeastern Brazil: Praia das Neves (21°15′S; 40°58′W), in Espírito Santo state and Grussaí (21°44′S; 41°02′W), in Rio de Janeiro state. The two skink species are abundant in both areas. Praia das Neves and Grussaí constitute typical 'restinga' habitats, which are characterized by sandy soils and xerophilic vegetation, and these habitats occur throughout most of the Brazilian coast (Suguio & Tessler, 1984). Although the two localities are only some 42 km apart, they are separated by the Itabapoana river, which lies at the boundary of the two states and could act as a geographical barrier for the *Mabuya* populations.

Lizards were euthanized with ether and their snout-vent length (SVL) was measured with a digital caliper (to the nearest 0.1 mm), before fixation in 10% formalin and preservation in 70% ethanol. In the laboratory, the digestive tract, body cavity, liver and lungs of each individual were examined for the presence of helminths under a stereomicroscope. All helminths found were removed and prepared as temporary slides, for identification: nematodes were cleared in phenol; pentastomids, trematodes, cestodes and acanthocephalans were stained in haematoxylin and cleared in xylene.

Ecological terminology used throughout the text follows Bush *et al.* (1997). Infracommunity diversity was estimated, for samples of each population, using Brillouin's diversity index (HB; values calculated using natural logarithms). The average HB value (± one standard deviation) of all infracommunities within a sample was considered as the mean infracommunity diversity of the referred population. The similarity of

Table 1. The prevalence and mean intensity of infection for each helminth species infecting *Mabuya agilis* and *M. macrorhyncha* in Praia das Neves and Grussaí, southeastern Brazil.

	Praia das Neves				Grussaí			
	M. agilis (n = 11)		*M. macrorhyncha* (n = 11)		*M. agilis* (n = 28)		*M. macrorhyncha* (n = 14)	
Helminth species	P (%)	M	P (%)	M	P (%)	M	P (%)	M
Pentastomids								
Raillietiella sp. (larva)	9.1	1	–	–	3.6	1	–	–
Acanthocephalans								
Centrorhynchidae (cystacanths)	90.9	15.0 ± 10.7 (1–37)	90.9	35.5 ± 45.8 (1–149)	57.1	6.3 ± 10.7 (1–43)	7.1	3
Trematodes								
Paradistomum parvissimum	9.1	2	18.2	2.0 (1–3)	7.1	4.0 (1–7)	28.6	4.5 ± 3.8 (2–10)
Pulchrosomoides elegans	–	–	9.1	1	–	–	–	–
Cestodes								
Oochoristica ameivae	36.4	5.0 ± 4.7 (1–10)	27.3	1	75.0	5.5 ± 4.3 (1–16)	28.6	1.3 ± 0.5 (1–2)
Nematodes								
Acuariidae (larva)	63.6	4.1 ± 4.3 (1–12)	63.6	11.1 ± 11.5 (2–36)	53.6	6.7 ± 6.8 (1–21)	–	–
Hexametra boddaertii (larva)	–	–	–	–	53.6	4.5 ± 6.8 (1–28)	35.7	2.4 ± 1.1 (1–4)
Parapharyngodon sceleratus	90.9	4.1 ± 2.3 (1–9)	18.2	1.5 (1–2)	53.6	2.1 ± 1.2 (1–4)	7.1	2
Physaloptera sp. (larva)	9.1	2	27.3	2.0 ± 1.0 (1–3)	10.7	2.0 ± 1.7 (1–4)	7.1	2
Physalopteroides venancioi	45.5	2.6 ± 1.5 (1–5)	9.1	2	14.3	1	7.1	2

P, prevalence (%) of infection; M, mean intesity of infection ± one standard deviation, with the range in parentheses.

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Table 2. Characteristics of the helminth communities in *Mabuya agilis* and *M. macrorhyncha* from Praia das Neves and Grussaí, southeastern Brazil.

	Praia das Neves		Grussaí	
	M. agilis (n=11)	*M. macrorhyncha* (n=11)	*M. agilis* (n=28)	*M. macrorhyncha* (n=14)
Mean host SVL (range)	73.4 (58.6–87.0) mm	66.5 (50.2–73.5) mm	62.8 (49.7–80.0) mm	61.0 (53.0–72.6) mm
Total prevalence (%)	100	100	96.4	71.4
No. of helminth species	8	8	9	7
Mean species richness/host (infected hosts only)	3.55 ± 1.13	2.64 ± 1.12	3.44 ± 1.37	1.70 ± 0.48
Mean species richness/host (all hosts)	3.55 ± 1.13	2.64 ± 1.12	3.28 ± 1.44	1.21 ± 0.89
Max. no. of species/host	5	5	7	2
Mean intensity	23.46 ± 15.83	35.50 ± 45.84	16.19 ± 16.67	4.2 ± 3.29
Mean abundance	23.46 ± 15.83	35.50 ± 45.84	15.57 ± 16.66	3.0 ± 3.37
Max. no. of worms/host	55	188	73	12
No. species/host – SVL relationship	r = 0.66; $P < 0.05$	r = 0.60; $P = 0.052$	r = 0.50; $P < 0.01$	r = 0.71; $P < 0.05$
Mean infracommunity diversity	0.742 ± 0.232	0.430 ± 0.183	0.689 ± 0. 382	0.286 ± 0.203
Percentage of hosts with a single helminth species	0	9.1%	3.6%	21.4%

The relationship between the number of species per host (considering only infected individuals) and host snout-vent length (both log-transformed) is represented, in each case, by the regression coefficient (r) and the *P*-value. Mean infracommunity diversity is represented by the mean Brillouin's index (HB; ± one standard deviation).

component communities between samples were estimated by Sorensen's indexes for qualitative (C_S) and quantitative (C_N) data (Magurran, 1988), using the abundance (*sensu* Bush *et al*., 1997) values of each helminth species for each sample in the latter case.

The relationship between lizard SVL and number of helminth species per individual (infracommunity richness) was tested for each sample using simple regression analysis, after log-transforming both variables. Mean infracommunity richness was compared among samples using the Mann-Whitney U-test statistic (non-parametric), since the values were not normally distributed (according to a previously performed goodness-of-fit test).

Results

Ten helminth species were recovered from the skinks: one pentastomid (*Raillietiella* sp.), one acanthocephalan (an unidentified centrorhynchid), two digenean trematodes (*Paradistomum parvissimum* (Travassos, 1918) and *Pulchrosomoides elegans* Freitas & Lent, 1937), one cestode (*Oochoristica ameivae* (Beddard, 1914)), and five nematodes (*Hexametra boddaertii* (Baird, 1860), *Parapharyngodon sceleratus* (Travassos, 1923), *Physalopteroides venancioi* (Lent, Freitas & Proença, 1946), *Physaloptera* sp. and an unidentified acuariid). Centrorhynchid acanthocephalans were found only in the form of cystacanths and three of the nematodes (*H. boddaertii*, *Physaloptera* sp. and the acuariid) and the pentastomid were found only as larvae. Most of the helminths were relatively site-specific in both host species, with *Paradistomum parvissimum* occurring only in the gall bladder, *O. ameivae* only in the smal intestine, *Parapharyngodon sceleratus* in the small and large intestines (especially the former), *Physaloptera* sp. mostly in the stomach (occasionally in the intestine) and *Physalopteroides venancioi* in the stomach and small intestine. The single specimen of *Pulchrosomoides elegans* was found in the stomach of *M. macrorhyncha*. The remaining helminth species (*Raillietiella* sp., *H. boddaertii*, the centrorhynchid and the acuariid) were found mainly outside the digestive tract, either loose in the body cavity or (in the case of centrorhynchids and most acuariids) encysted in the stomach and intestinal walls, peritoneal membranes, liver and lungs. *Hexametra boddaertii* was also frequently found encysted in the lining of the body wall and in the peritoneal membranes and, on two occasions, inside the stomach. Acuariids were also occasionally found inside the stomach and small intestine of hosts. Data on the prevalence and intensity of infection for each helminth species for each population of *M. agilis* and *M. macrorhyncha* are given in table 1. Except for the trematode *Pulchrosomoides elegans* (not found at Grussaí) and the nematode *H. boddaertii* (absent in Praia das Neves), the same helminth species occurred at both localities.

Parameters of helminth communities of *M. agilis* and *M. macrorhyncha* at each study site are shown in table 2. Overall prevalences were high (70–100%), indicating that both skink species were frequently infected by helminths in both localities (table 2). Also, most infected hosts harboured more than one helminth species, although in the Grussaí sample of *M. macrorhyncha* no individual host

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harboured more than two helminth species (table 2). The richness of component communities did not differ much among the four populations, though both the number of helminth species per host and the number of individual helminths per host were reduced for the *M. macrorhyncha* sample from Grussaí (table 2). The relationship between infracommunity richness and host SVL was positive and significant for three of the populations sampled and marginally significant for the remaining one (table 2). Mean infracommunity richness did not differ significantly between the two skink species at Praia das Neves ($U = 87.5$; $P = 0.066$), but was significantly greater for *M. agilis* than for *M. macrorhyncha* at Grussaí ($U = 244$; $P < 0.001$). Infracommunities of *M. macrorhyncha* tended to be less diverse than those of *M. agilis*. Diversity of infracommunities was significantly higher for *M. agilis* than for *M. macrorhyncha* both at Praia das Neves ($U = 104$; $P < 0.005$) and at Grussaí ($U = 228$; $P = 0.001$), but did not differ between localities for either species (*M. agilis*: $U = 134.5$; $P = 0.65$; *M. macrorhyncha*: $U = 32$; $P = 0.10$).

Qualitative and quantitative similarity values between helminth communities are presented in table 3. Qualitative similarities between component communities were always high (≥ 0.8), whereas quantitative similarities were somewhat lower, ranging from 0.06 to 0.54 (table 3).

Discussion

The present data indicate that these two species of *Mabuya* are frequently infected by helminths in both localities, as shown by the high overall prevalences of infection. High prevalences were also observed in studies on *M. agilis* and *M. macrorhyncha* in other restinga areas (Van Sluys *et al.*, 1997; Ribas *et al.*, 1998; Vrcibradic *et al.*, 2000a, 2001, 2002), which indicates that populations of these two skink species inhabiting restinga habitats, in general, are characterized by high rates of helminth infections. The richness of the helminth fauna in both *M. agilis* populations studied here exceeded that of a conspecific population studied in another restinga area by Vrcibradic *et al.* (2002). Also, in the latter population, five of seven helminth species found had prevalences of 12% or less, with two helminth species dominating the component community; whereas in each of the skink populations studied here, prevalences were moderate to high (45–90%) for half or more of the helminth species. Comparisons with other *M. agilis* populations are limited by the fact that only nematodes were surveyed in those studies (Van Sluys *et al.*, 1997; Ribas *et al.*, 1998; Vrcibradic *et al.*, 2000a). The helminth fauna of *M. macrorhyncha* from Praia das Neves is comparable, in species richness and infection rates, to that of a more northerly conspecific population studied by Vrcibradic *et al.* (2001) at the restinga habitat of Trancoso, in Bahia state.

The occurrence of *Pulchrosomoides elegans* in *M. macrorhyncha* and of *Paradistomum parvissimum* and the genus *Raillietiella* Sambon, 1910 in *M. agilis* represent new host records. The cystacanths found in the present study are identical to those previously reported by Vrcibradic *et al.* (2001, 2002) from the same hosts in two other localities, except that the specimens were erroneously included in the family Echinorhynchidae. Therefore, the Echinorhynchidae should be dropped from the list of helminth taxa known to parasitize *Mabuya agilis* and *M. macrorhyncha*, and replaced by the Centrorhynchidae, the cystacanths of which have previously been reported from a number of other reptilian and amphibian hosts in Brazil (Travassos, 1926).

Most helminth species recorded here are known to infect either or both *Mabuya* species in other restinga areas (Van Sluys *et al.*, 1997; Ribas *et al.*, 1998; Vrcibradic *et al.*, 2000a, 2001, 2002). The exception is *Pulchrosomoides elegans*, which was originally described from the stomach of an iguanid lizard, *Iguana iguana* (Linnaeus, 1758) (= *I. tuberculata* Laurenti, 1768), by Freitas & Lent (1937) and, up to now, had not been reported from other hosts. However, Yamaguti (1958) believes the type of *P. elegans* to be a wrongly identified member of the genus *Echinostoma* Rudolphi, 1809 (whose species typically parasitize birds) and, therefore, regards its occurrence in the lizard as accidental. This may also be the case for the specimen found by us in the stomach of a female *M. macrorhyncha*, though it is premature to draw conclusions until the taxonomic status of *P. elegans* is clarified, and this is beyond the scope of the present study.

Of the ten helminth species found infecting the two *Mabuya* species in this study, only one (*Parapharyngodon sceleratus*) was monoxenic. This does not agree with Aho's (1990) observation that helminth faunas of lizards and other terrestrial reptiles tend to be enriched by species with direct life-cycles. It is also interesting to note that 50% of helminth species found were present only as immature stages (larvae or cystacanths). With the exception of *Raillietiella* sp., these helminth species do not use skinks as their final hosts. Although *Raillietiella* sp. was found only as larvae in *M. agilis*, it is possible that

Table 3. The similaritiy of the helminth fauna of component communities of *Mabuya agilis* and *M. macrorhyncha* in Praia das Neves and Grussaí.

	M. a. P. Neves	*M. m.* P. Neves	*M. a.* Grussaí	*M. m.* Grussaí
M. a. P. Neves		0.538	0.499	0.088
M. m. P. Neves	0.875		0.295	0.057
M. a. Grussaí	0.941	0.824		0.230
M. m. Grussaí	0.800	0.800	0.875	

m.a., *Mabuya agilis*; *m.m.*, *M. macrohyncha*.
Values above and below the diagonal represent Sorensen's indexes of similarity for quantitative (C_N) and qualitative data (C_S), respectively.

skinks may also act as final hosts for these parasites, as adult worms of many species of *Raillietiella* have been recorded in several lizard species, including members of the genus *Mabuya* (Ali *et al.*, 1981, 1985; Rego, 1983; Riley *et al.*, 1991). In the cases of *H. boddaertii*, adults of which are parasites of snakes (Sprent, 1978), and of the centrorhynchid acanthocephalans and acuariid nematodes, both of which probably have birds as their final hosts (Nickol, 1985; Anderson, 2000), lizards apparently serve as paratenic hosts. In the case of *Physaloptera* sp., larvae may not develop further in skinks for some unknown reason, although adult worms of this genus are known to infect several other lizard species in Brazil (Vrcibradic *et al.*, 2002). Other studies (Sharpilo, 1976, 1983; Sharpilo *et al.*, 2001) have shown that helminth communities of lizards and other reptiles are commonly enriched by several species that use such animals as paratenic or (less commonly) intermediate hosts, and this agrees with the present results. On the other hand, the helminth species that undoubtely use the two skinks as final hosts (i.e. *O. ameivae, Paradistomum parvissimum, Parapharyngodon sceleratus* and *Physalopteroides venancioi*) are also known to infect several other lizards (and occasionally snakes) of different families (e.g. Travassos, 1965; Travassos *et al.*, 1969; Baker, 1987; Vrcibradic *et al.*, 2000a,b) and, in one case (*P. venancioi*), also an anuran amphibian (Lent *et al.*, 1946). Thus, the helminth fauna of the two *Mabuya* species studied here are composed predominantly of host-generalists, as is typical of the helminth faunas of reptiles and amphibians in general (e.g. Aho, 1990).

In both localities, but notably at Grussaí, trematodes were more frequent in *M. macrorhyncha* than in *M. agilis*. *Mabuya macrorhyncha* is known to be strongly associated with ground bromeliads, especially those of the so-called 'tank-bromeliad' type, on restinga habitats, basking and foraging on and among their leaves, whereas *M. agilis* is typically ground-dwelling (Rebouças-Spieker, 1974; Vrcibradic & Rocha, 1996; Rocha *et al.*, 2000). Tank bromeliads, as their name implies, are known to store large quantities of water between their leaves, thus constituting an important source of free water for many organisms in the xeric restinga habitats (Oliveira *et al.*, 1994). Whether the bromelicolous *M. macrorhyncha* may be more prone to acquire trematodes, whose life-cycles depend on water, than its sympatric ground-dwelling congener requires further studies based on larger samples. There was also a tendency for the nematode *Parapharyngodon sceleratus* to occur with higher prevalences in *M. agilis* than in *M. macrorhyncha* in both localities. The same trend was also observed in another restinga habitat where the nematode fauna of the two skink species were studied by Ribas *et al.* (1998), who suggested that this was possibly related to interspecific differences in microhabitat use by the hosts. As *P. sceleratus* is a monoxenic species, infecting the lizards through direct ingestion of its eggs scattered over the ground, the mainly terrestrial *M. agilis* would be more susceptible to acquire that nematode than the more scansorial *M. macrorhyncha*. This hypothesis is supported by the results of the present study. The cases of *Paradistomum parvissimum* and *Parapharyngodon sceleratus* mentioned above seem to illustrate the importance of host ecology on the structuring of helminth communities (Aho, 1990; Janovy *et al.*, 1992).

Infracommunities of *M. agilis* tended to be richer and more diverse than those of *M. macrorhyncha*, irrespective of locality. Since most helminth species infecting these skinks have heteroxenic life-cycles, one may conclude that *M. agilis* has a broader diet than its congener and, thus, may be more likely to ingest greater numbers of intermediate hosts (i.e. arthropods) of these helminths. However, a study of the diet of these two skink species in another restinga locality have shown them to consume an equally broad range of prey types (Vrcibradic & Rocha, 1996). In any case, by foraging frequently among bromeliad leaves, *M. macrorhyncha* may be exposed to a different range of prey species (within a given arthropodan order) than the ground-dwelling *M. agilis*, and this may have implications on the differences in composition of helminth comunities between the two host species. According to Janovy *et al.* (1992), the structuring of parasite communities of amphibians and reptiles is influenced mainly by the relative probabilities of host individuals of acquiring the various parasite species, which in turn is affected by the ecological requirements of each host species. This may lead to differently structured parasite assemblages among closely related hosts and the present results seem to agree with this.

Qualitative similarities of the helminth fauna amongst the four samples were high, since the helminth species pool was about the same in both localities. This is not surprising, as both localities represent the same type of habitat and are geographically close. The main difference between the two localities in the composition of the component communities was the apparent absence of *H. boddaertii* from Praia das Neves. Since this nematode is known to infect both *Mabuya* species studied here with relative frequency in other restinga areas (Ribas *et al.*, 1998; Vrcibradic *et al.*, 2000a; this study), the fact that it was not recorded in a sample of 22 skinks suggests that its absence in the Praia das Neves site may be real and not merely due to undersampling. Although the reason for the absence of *H. boddaertii* from Praia das Neves is unknown, it is possible that the Itabapoana river may act as a geographical barrier for this particular species.

Quantitative similarities ranged from relatively high to very low. The highest values were found between species at Praia das Neves (0.54) and between the two *M. agilis* populations (0.50). The lowest values were found for pairs of samples including the *M. macrorhyncha* population of Grussaí, due to the low diversity of its component community. The latter sample was, nevertheless, more similar to the sympatric *M. agilis* one than to the remaining two, from Praia das Neves and this was partly due to the fact that *H. boddaertii*, which is absent from Praia das Neves, was relatively abundant in both Grussaí samples. These results were influenced somewhat by the high abundance of centrorhynchid acanthocephalans in the two samples from Praia das Neves, mainly due to the presence of a few individual hosts harbouring large numbers of cystacanths. The prevalence of this helminth species was also higher in Praia das Neves than in Grussaí, suggesting that, in the case of centrorhynchids, the local abundance may have a greater influence on component community differences than host ecology. In his survey of helminth communities of several North American reptile and amphibian taxa, Aho (1990) observed that the qualitative faunal similarity among closely related hosts from the same locality usually equalled, or exceeded, that among different populations of the same host species. In the present study, qualitative similarities were always high, irrespective of host species or locality. Quantitiative similarities varied more widely and were more difficult to explain, although they appeared to be strongly influenced by both intrinsic (the tendency of *M. agilis* to have richer infracommunities than *M. macrorhyncha*) and extrinsic (the local presence/absence or higher/lower abundance of a given helminth species) factors.

Within the component communities of the two *Mabuya* species in both localities, helminths utilizing the skinks as final hosts were all site-specialists and differed from each other in site preferences, whereas the helminth species which used them as paratenic hosts occurred mainly outside the digestive tract. This indicates that the potential for interspecific interactions within the component communities associated with each skink population is low, and therefore such helminth assemblages can be considered non-interactive, which seems to be the rule for reptilian and amphibian hosts (Aho, 1990; Janovy *et al*., 1992; Sousa, 1994).

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