

Intestinal helminth communities of *Podarcis bocagei* and *Podarcis carbonelli* (Sauria: Lacertidae) in NW Portugal

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Summary

A survey of gastrointestinal helminth communities of *Podarcis bocagei* and *Podarcis carbonelli* (Sauria: Lacertidae) from NW Portugal was conducted to determine the prevalence, intensity and diversity of intestinal parasites in these lizards. A few parasite species were found in both hosts, their prevalences, mean intensities and abundances of infection being low or very low. Low values of richness and abundance of parasite species were also found in the helminth infracommunities of individuals of both host species. These low values of parameters of infection and diversity are discussed and compared between both host species and among other Iberian lacertid lizards.

Key words: helminth communities; lizards; Iberian Peninsula

Introduction

Among the four species of lizards of the genus *Podarcis* currently recognised in the Iberian Peninsula, two of them are endemic to the Western part of this region, *Podarcis bocagei* Seoane, 1884 and *P. carbonelli* Pérez-Mellado, 1981 (Pleguezuelos *et al.*, 2002). Both were considered conspecific since the later was described as a subspecies of the former (Pérez-Mellado, 1981). Nevertheless, researches on morphology (Harris & Sá Sousa, 2001), genetic divergence (Harris & Sá Sousa, 2001, 2002; Harris *et al.*, 2002) and behaviour (Barbosa *et al.*, 2005) recently showed that *P. carbonelli* must be considered as a distinct species (Sá Sousa & Harris, 2002). Another evidence in favour to consider them as different species is their pattern of geographical distribution (Harris & Sá Sousa, 2001). Both forms live in western Iberian Peninsula, the river Douro being the main geographical barrier separating *P. bocagei*

(N of Douro) from *P. carbonelli* (S of Douro) (Sá Sousa, 2001). However, *P. bocagei* also has a small range south of the river in the area of the Douro Litoral province (Portugal) which constitutes a contact zone between both species. In some localities in which both species have been found in strict syntopy the species maintain their identity (Carretero *et al.*, 2002). A possible biogeographic scenario would be a recent invasion of *P. bocagei* south of the Douro due to human interference (Sá Sousa, 2001).

Studies on helminth fauna of continental Iberian lizards of the genus *Podarcis* are partial and scarce (Roca *et al.*, 1986a; García-Adell & Roca, 1988), with limited helminthological data for *P. carbonelli* from the Spanish Central System (Roca *et al.*, 1989, as *P. bocagei carbonelli*) and none for *P. bocagei*. Thus, this work represents an opportunity to know for the first time the infracommunities and the component community of *P. bocagei* and to complete the knowledge on the helminth communities parasitizing *P. carbonelli*. We also have an excellent opportunity to: (i) compare the helminth communities of both hosts in a peculiar contact area; and (ii) compare the helminth communities of *P. bocagei* and *P. carbonelli* with those of other lacertid lizards of the Iberian Peninsula.

Material and Methods

Sampling was carried out in three coastal localities from the Douro litoral, NW Portugal: Espinho-Granja, UTM squares 29T NF24 and NF34, for both hosts; Torreira near Aveiro, 29T NF21, for *P. carbonelli* and Mindelo-Vila Chã, 29T NF27, for *P. bocagei*. All three sites were geographically close (within a range of 40 km) and harboured similar habitats, humid dunes covered by psammophilic vegetation (see Carretero *et al.*, 2002 for a more detailed

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description). Climate regime was maritime Atlantic with warm mid-summers and mild, rainy winters; annual temperature averaged 12°C and total annual precipitation was 1000 – 1200 mm (Direcção Geral do Ambiente, 1995).

In all, 249 specimens of *P. bocagei* and 257 of *P. carbonelli* were collected. Lizards were immediately carried to the laboratory, sacrificed and frozen. These specimens were used not only for this study but also for analysing the cycles of gonads and fat reserves (Carretero *et al.*, submitted a,b) as well as morphometrics (Carretero *et al.*, 2003; Kaliontzopoulou, 2004) and trophic ecology (in progress). Digestive tracts were fixed in 70 % alcohol prior to examination. Helminths were removed, washed, fixed and mounted according to standard techniques (for details see Roca, 1985). Parasites were identified, when possible, to species, and the number and location of individuals of each species were recorded.

The use of descriptive ecological terms followed Bush *et al.* (1997). Brillouin's index was used for calculating diversity according to Magurran (2004). A prevalence of 10 % was adopted as the upper limit for identifying satellite species (Kennedy & Bakke, 1989). Species with prevalences $10\% < p < 30\%$ were assigned as secondary species

(Hanski, 1982; Roca, 1993).

Results

A total of 5 helminth species were recovered from both hosts (1 Trematoda, 1 Cestoda, and 3 Nematoda). The nematode *Spauligodon carbonelli* was found at the end of the large intestine (rectum), and the remaining species were found in the small intestine. The trematode *Brachylaima* sp. and the nematode Spirurida gen. sp. were recorded as larval forms whereas the other species were adults.

The total number of parasite species and the infection parameters for each host species are shown in Tables 1, 2 respectively. Both host species did not harbour identical parasite communities, although compositional similarities do exist being absent only Spirurida gen. sp. in the helminth community of *P. carbonelli* (see Tables 1, 2). The overall prevalence of infection was 13.7 % in *P. bocagei*, and 14 % in *P. carbonelli*.

Only *Skrjabinelazia hoffmanni* from *P. bocagei* showed 10 % prevalence. All the remaining species infected less than 10 % of the host populations. Tables 3 shows the diversity parameters for the helminth infracommunities of both hosts.

Table 1. Infection parameters of helminth species parasitizing *Podarcis bocagei* in NW Portugal (n = 249)

Helminth species	Site	Prevalence (%)	Mean Intensity*	Mean Abundance*
DIGENEA				
<i>Brachylaima</i> sp.	intestine	0.4	–	–
CESTODA				
<i>Oochoristica gallica</i>	intestine	2.4	2.8 ± 2.6 (1 – 8)	0.07 ± 0.6 (0 – 8)
NEMATODA				
<i>Skrjabinelazia hoffmanni</i>	intestine	10.0	4.0 ± 5.6 (1 – 27)	0.4 ± 2.1 (0 – 27)
<i>Spauligodon carbonelli</i>	caecum	0.4	–	–
<i>Spirurida</i> gen. sp.	intestine	0.4	–	–

* Values are given as the mean ± SD with the range in parentheses

Table 2. Infection parameters of helminth species parasitizing *Podarcis carbonelli* in NW Portugal (n = 257)

Helminth species	Site	Prevalence (%)	Mean Intensity*	Mean Abundance*
DIGENEA				
<i>Brachylaima</i> sp.	intestine	1.2	4.7 ± 6.4 (1 – 12)	0.05 ± 0.8
CESTODA				
<i>Oochoristica gallica</i>	intestine	1.2	2.7 ± 1.5 (1 – 4)	0.03 ± 0.3
NEMATODA				
<i>Skrjabinelazia hoffmanni</i>	intestine	4.3	1.5 ± 0.5 (1 – 2)	0.06 ± 0.3 (0 – 2)
<i>Spauligodon carbonelli</i>	caecum	7.8	8.8 ± 9.0 (1 – 32)	0.7 ± 3.4 (0 – 32)

* Values are given as the mean ± SD with the range in parentheses

Table 3. Overall diversity parameters of the helminth infracommunities from *Podarcis bocagei* and *P. carbonelli* in NW Portugal

Host	n	No. of helminth species/host*	No. of helminths/host*	Brillouin's index*	Proportion of sample with 0 or 1 helminth species
<i>P. bocagei</i>	249	0.14 ± 0.34 (0 – 1)	0.49 ± 2.19 (0 – 27)	0	1
<i>P. carbonelli</i>	257	0.14 ± 0.36 (0 – 2)	0.83 ± 3.5 (0 – 32)	0.001 ± 0.02 (0 – 0.34)	0.99

* Values are given as the mean ± SD with the range in parentheses

Discussion

The presence of *Brachylaima* sp. (*metacercariae*) in 3 of the examined lizards must be considered as atypical, probably due to ingestion of snails that are intermediate hosts for this trematode. Terrestrial gastropods and rodents are intermediate and definitive hosts, respectively, in the life cycle of *Brachylaima* spp. (González-Moreno, 2002). These snails are not usual prey of *P. bocagei* and *P. carbonelli* (Pérez-Mellado, 1982, 1983) although they are sporadically consumed in the populations analysed (unpubl. data). Immature forms of *Brachylaima* were reported previously in *P. carbonelli* from the Spanish Central System (Roca *et al.*, 1989), and also in *Podarcis lilfordi* and *P. pityusensis* from the Balearic Islands (Western Mediterranean), in all cases with low prevalences (0.9 %; 0.8 %; 0.2 %, respectively) (Roca *et al.*, 1989; Roca & Hornero, 1994).

The remaining helminths, are species usually found as parasites of lacertid lizards and other reptile hosts. *S. carbonelli* can be considered as *Podarcis* specialist (Edwards & Bush, 1989; Roca & Hornero, 1994), since it only parasitizes hosts of this genus (García-Adell & Roca, 1988; Roca *et al.*, 1989). *Oochoristica gallica*, *Sk. hoffmanni*, and *Spirurida* gen. sp. (larvae) are generalist species, because they have been also found in other saurian hosts (Li, 1934; Dolfus, 1954; Sharpilo, 1976; Roca & Hornero, 1994; Martin & Roca, 2004).

Most helminth species occurred at low prevalence. The nematode *Sk. hoffmanni* can be considered as a secondary species in the component community of *P. bocagei*, whereas the remaining helminths are satellite species. All the helminths are satellite species in the community of *P. carbonelli*. There are no core species (prevalence of infection 30 % or higher, see Roca, 1993) in either hosts in these populations. The low values of prevalences and mean intensities of infection (Tables 1 and 2) indicate that many members of the helminth infracommunities occur only irregularly and occasionally (Martin & Roca, 2005). Only the nematode *Sk. hoffmanni* appears to be a common parasite of *P. bocagei*. This agrees with the typical pattern of helminth infection in many reptiles, i. e., few species occur frequently, few species occur with moderate prevalence (e. g. *S. hoffmanni* in *P. carbonelli*, *S. carbonelli* in both hosts), and many species are rare (Aho, 1990; Martin & Roca, 2005).

Values of diversity index (Table 3) for both hosts have been revealed as the poorest of all values known for eura-

sian reptiles. Thus, Sanchis *et al.* (2000) found “extremely poor infracommunities” in *Lacerta (Zootoca) vivipara* from the Pyrenees (Spain) (mean value of Brillouin's index of diversity = 0.0025 ± 0.029, range = 0 – 0.34). Nevertheless, helminth infracommunities of *P. bocagei* and *P. carbonelli* showed even lower diversity. The causes of the very low diversity for *L. (Z.) vivipara* were the small body size, ecological isolation and few interactions with other reptile and amphibian species in the population studied (Sanchis *et al.*, 2000). It seems that this pattern is similar in *P. bocagei* and *P. carbonelli* from NW Portugal. Sandy areas have been revealed as zones where recruitment of parasites by lizard hosts is low; thus Roca *et al.* (1986a,b) found very poor helminth communities in lizards such as *Psammodromus algirus*, *Psammodromus hispanicus*, *Podarcis hispanica* and *Acanthodactylus erythrurus* living in Mediterranean dunes, perhaps indicating that some peculiar abiotic and biotic conditions of these areas constrain the presence of parasite species (Roca & Lluch, 1988). Moreover, other characteristic of reptile hosts, such as ectothermy, simplicity of the alimentary canal, generalist diet, and low vagility, have been cited as responsible for their depauperate and isolationist helminth communities (Kennedy *et al.* 1986; Roca & Hornero, 1994; Martin & Roca, 2004).

Global prevalences of infection were also very low in *P. bocagei* and *P. carbonelli*. Thus, prevalences of infection of other lacertid lizards in the Iberian Peninsula usually were higher than 45 % and values higher than 60 % were found in lizards from insular ecosystems (Martin & Roca, 2004). Even the lowest global prevalence found in *L. (Z.) vivipara* (39.4 %) (Sanchis *et al.*, 2000) was higher than prevalences found in both hosts from NW Portugal. Host densities and physiography have been pointed out as factors related to high or low values of prevalence. In general, when hosts occur at high densities, they show high prevalences of infection by helminths (Martin & Roca, 2004). As population densities of both hosts are high in the studied area, it seems that physiography of prospected areas are responsible for the low values of prevalence. In fact, previous studies carried out on *P. carbonelli* in the W Central System (central Iberian Peninsula) showed a global prevalence of 66.1 % (Roca *et al.*, 1989; Martin & Roca, 2004), and also showed the presence of some helminth species not found in this research: *Nematotaenia tarentolae*

and *Mesocestoides* sp. (larvae) (Cestoda); *Skrjabinodon medinae*, *Skrjabinelazia pyrenaica* and *Skrjabinelazia taurica* (Nematoda). This fact suggests that different biotopes provide different opportunities for the behaviour of lizards regarding feeding and cohabitation with other species, and also suggests the absence or low frequency, in coastal Portugal, of arthropods that could be intermediate hosts in the life cycles of heteroxenous species, such as *N. tarentolae*, *O. gallica*, and *Skrjabinelazia* spp.

Helminth infracommunities (Table 3) and component communities (Tables 1 and 2) of both hosts were very similar, suggesting on the one hand the use of similar biotopes and resources of both hosts (Carretero *et al.*, 2002; unpubl. data), and on the other hand a high degree of interactions among neighbouring populations of *P. bocagei* and *P. carbonelli*. This contrasts with the deep evolutionary divergence (10 – 12 % in cyt-b mtDNA, Harris *et al.*, 2002) between both lizard hosts which are not even sister groups but are only related with an ancestor in the early Pliocene (7My) also shared with the NW and SW forms of *Podarcis hispanica* (Harris *et al.*, 2002; Pinho *et al.*, submitted). Both contrasting results suggest that helminth fauna is a sign of ecological similarity rather than an indicator of evolutionary relationships in this host group.

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