

Parasite specificity in *Podarcis bocagei* and *P. carbonelli* (Lacertidae) from NW Portugal: a host-parasite history

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Host parasite specificity is related to several factors including the type of life cycle of the parasite, the habitat occupied by both parasites and hosts, and the food habits of the hosts. In this work, gastrointestinal helminths in two congeneric lacertid lizards, *Podarcis bocagei* and *Podarcis carbonelli* living in syntopy, have been analysed. Out of four helminth species found, three of them, the trematode *Brachylaima* sp., the cestode *Oochoristica gallica* and the nematode *Skrjabinelazia hoffmanni*, have indirect life cycles while the nematode *Spauligodon carbonelli* has a direct life cycle. Heteroxenous helminths showed low host specificity whereas *S. carbonelli* may be placed at an intermediate position in a continuum of the degree of specificity.

Key words: host-parasite relationships; Iberian Peninsula; lizards; parasites.

Especificidad parasitaria en *Podarcis bocagei* y *P. carbonelli* del NO de Portugal: una historia de parásitos y hospedadores. La especificidad parasitaria está relacionada con diversos factores entre los que se incluyen el tipo de ciclo vital del parásito, el hábitat que ocupan parásito y hospedador, o la estrategia alimentaria de este último. Se analizaron los hospedadores *Podarcis bocagei* y *Podarcis carbonelli* (Lacertidae) que habitan un área de sintopía estricta y se estudiaron sus helmintos gastrointestinales. De las cuatro especies de helmintos detectadas, tres de ellas, el trematodo *Brachylaima* sp., el cestodo *Oochoristica gallica* y el nematodo *Skrjabinelazia hoffmanni*, tienen ciclos vitales indirectos mientras que el nematodo *Spauligodon carbonelli* presenta un ciclo directo. Los helmintos de ciclos heteroxenos mostraron una especificidad baja mientras que *S. carbonelli* ocupa una posición intermedia en un continuo de la especificidad parasitaria.

Key words: lagartijas; parásitos; Península Ibérica; relaciones parásito-hospedador.

The concept of co-evolution between parasites and hosts is based on the fact that the gradual host-parasite adaptation has been adjusting over evolutionary time in mutual gene interaction to get a balanced relationship (COMBES, 1995; MARTÍNEZ-FERNÁNDEZ & CORDERO DEL CAMPILLO, 2007). Host specificity is defined as the

extent to which a parasite taxon is restricted in the number of host species used at a given stage in the life cycle (POULIN, 1998). Highly host-specific parasites are restricted to one host species (extreme stenoxeny) and specificity declines as the number of suitable host species increases (eurixeny) (POULIN, 1998). To understand why some

parasites are highly host specific and others are not, it is firstly necessary understand how parasites and hosts have co-evolved since the origin of their association (Poulin, loc. cit.). Specificity is related to diverse conditions, as life cycle of the parasite, ecological factors, or physiological characteristics of parasites and hosts, among others, although its molecular bases are still poorly known (ORTEGA-MORA & ROJO-VÁZQUEZ, 2007).

Lacertid lizards *Podarcis bocagei* (Seoane, 1884) and *P. carbonelli* Pérez-Mellado, 1981 are suitable for the study of host-parasite specificity because: (i) both are considered paraphyletic species (LIMA *et al.*, 2008), and (ii) show a peculiar geographical distribution in Douro littoral region (NW Portugal) including a strictly syntopic area (CARRETERO *et al.*, 2002).

In this study I have analysed the gastrointestinal helminth communities for both hosts in order to know the type and degree of specificity of the different helminth species found.

Eighty seven specimens of *P. bocagei* and 117 of *P. carbonelli* were caught by noose and by hand in Espinho and Granja (UTM 10 x 10 km squares, 29T NF24 and NF34). Captures were made in April and Septem-

ber 2001, and January and August 2002. The searched region is a narrow sandy area consisting in humid dunes covered by psammophilic vegetation, in which both host species are strictly syntopic (CARRETERO *et al.*, 2002). Lizards were immediately transported to the laboratory, humanely sacrificed with an overdose of chloroform, and analysed for gastrointestinal helminths, which were removed, washed, fixed and mounted according to standard parasitological techniques (GALDÓN, 2007). Helminths were identified as accurate as possible according adequate bibliography.

Four helminthic species were found (Fig. 1), one trematode (*Brachylaima* sp. *metacercariae*), one cestode (*Oochoristica gallica*) and two nematodes (*Spauligodon carbonelli* and *Skrjabinelazia hoffmanni*). Three of these species were common to both hosts, and *S. carbonelli* was found in *P. bocagei* but not in *P. carbonelli*. Table 1 shows their prevalence of infection in each host.

Although BUTCHER & GROVE (2005) suggested that the Australian shingleback lizard species (*Tiliqua rugosa*) may be a definitive hosts for *Brachylaima cribbi*, the presence of *metacercariae* (larval forms) of *Brachylaima* sp. in both Iberian hosts in study may be considered as accidental parasitism. This is considered when a parasite reaches a wrong host in which it is unable to complete its development. As reptiles are usually not definitive hosts for these trematodes, the presence of *metacercariae* of *Brachylaima* spp. in some Iberian lizards (see ROCA & HORNERO, 1994) is probably due to the ingestion of some terrestrial snails, which are second intermediate hosts (GONZÁLEZ-MORENO, 2002).

Table 1: Prevalence of infection of the helminths found in each host.

Helminth species	<i>P. bocagei</i> (N = 87)	<i>P. carbonelli</i> (N = 117)
<i>Brachylaima</i> sp.	1.2%	1.7%
<i>Oochoristica gallica</i>	6.9%	2.6%
<i>Spauligodon carbonelli</i>	1.2%	-
<i>Skrjabinelazia hoffmanni</i>	6.9%	4.3%

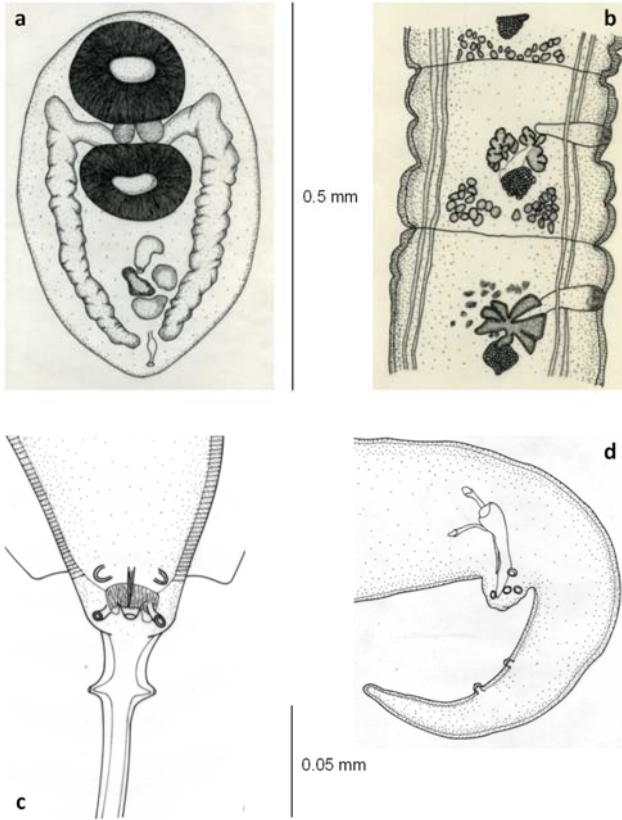


Figure 1: Parasites found in *Podarcis* lizards. (a) *Brachylaima* sp. metacercariae from *P. bocagei*. (b) *Ochoristica gallica* from *P. carbonelli*, mature proglotids. (c) *Spauligodon carbonelli* from *P. carbonelli*: ♂ caudal end of body, ventral view. (d) *Skrjabinelazia hoffmanni* from *P. bocagei*: ♂ caudal end ventro-lateral view.

The nematode *S. hoffmanni* is a generalist species (*sensu* EDWARDS & BUSH, 1989) that has been recorded in some genera of Palearctic lacertid lizards, as *Podarcis*, *Darevskia* and *Lacerta* (GARCÍA-ADELL & ROCA, 1988; ROCA *et al.*, 1989, 1990; ROCA & HORNERO, 1994; BISERKOV & KOSTADINOVA, 1998; YILDIRIMHAM *et al.*, 2011; V. Roca *et al.*, unpublished data). Also the cestode *O. gallica* is a generalist helminth species since it has been recorded in some lizards of the genera *Podarcis*, *Psammodromus* and *Iberolacerta* (GARCÍA-ADELL, 1987; GARCÍA-ADELL & ROCA, 1988; ROCA *et al.*, 1989; ROCA & HORNERO, 1994). As the nematode *S. carbonelli* has been only recorded in the lizards *Podarcis muralis*, *P. carbonelli* and *P. hispani-*

ca from the Iberian Peninsula (GARCÍA-ADELL & ROCA, 1988; ROCA *et al.*, 1989; GALDÓN *et al.*, 2006), it may be considered a *Podarcis* specialist. *Skrjabinelazia hoffmanni* and *O. gallica* would be close to the end of the low specificity (eurixeny) and far from the end of the high specificity (estenoxeny), in a continuum of the degree of specificity, whereas *S. carbonelli* would be located at an intermediate position between the two extremes (see references above).

Brachylaima sp., *O. gallica* and *S. hoffmanni* have indirect life cycles, and *S. carbonelli* has a direct life cycle. Probably, *O. gallica* has a diheteroxenic life cycle in which some terrestrial arthropod is involved as intermediate host (some coleopteran in-

sects and crustacean isopods have been recorded in the case of other species belonging to the genus *Oochoristica*, GARCÍA-ADELL, 1987). In the case of species of the genus *Skrjabinelazia*, CHABAUD *et al.* (1988) and ROCA *et al.* (1990) also pointed out a diheteroxenic life cycle in which a coprophagous insect would be the intermediate host. As larval forms of *Skrjabinelazia* spp. do not suffer any change in those insects, they should be considered paratenic hosts (CHABAUD *et al.*, 1988).

Since heteroxenic helminths infect both hosts, it seems that the area inhabited by the studied lizards is suitable for arthropods and gastropods which are intermediate hosts. Ecological factors favour the encounter and facilitates the flow of the life cycle of those parasites and so they show an ecological host specificity (ORTEGA-MORA & ROJO-VÁZQUEZ, 2007). Since both hosts show similar eating behaviour (strict carnivores, ROCA *et al.*, 2006), an ethological specificity should also be considered (Ortega-Mora & Rojo-Vázquez, loc. cit.). These two types of specificity do not need a long contact time in the evolution of both parasite and host, and so they fall close to the extreme of eurixeny in a continuum of the degree of specificity.

The more interesting helminth species regarding the relationships with their hosts is *S. carbonelli*. Its life cycle is direct, which means that the host lizards are infested through accidental ingestion of eggs that are associated with the substrate or adhered to the cloaca region of their hosts (ROCA *et al.*, 2006). So, why is the parasite present in *P. bocagei* but not in *P. carbonelli*? Related to the biotic and abiotic conditions in the area of syntopy where the hosts were

studied, the chances of contact with the infective eggs of *S. carbonelli* are the same for both lizards. Therefore, are ethological conditions determining the presence of the parasite in a host but not in the other? ROCA *et al.* (2006) pointed out that both host species are parasitized by *S. carbonelli* in other areas of NW Portugal and suggested that variation in the prevalence of infection of both hosts is due to local environmental conditions rather than to ethological differences between the two species, or to host specificity. However, this does not explain the absence of this nematode in *P. carbonelli* in the syntopic area.

Is it relevant to consider a type of phylogenetic specificity that implies the union over prolonged periods of host-parasite interspecific contact, in the course of their evolution? It does not seem appropriate to refer to host specificity *sensu stricto* since *S. carbonelli* has been recorded in several *Podarcis* species in the Iberian Peninsula. However, it is noteworthy the absence of this nematode in the endemic lacertid lizards of the Balearic archipelago, *Podarcis pityusensis* and *P. lilfordi*, in which *S. carbonelli* is apparently replaced by the congeneric *S. cabreræ* (ROCA & HORNERO, 1994). It should be considered the possibility of a common ancestor of both species of *Spauligodon* and a speciation of this genus parallel to the speciation of the ancestor that resulted in the current Balearic *Podarcis* (ALCOVER, 1988). From this point of view, it is pertinent to consider a presumable phylogenetic relationship of the nematodes *S. carbonelli* and *S. cabreræ* regarding the phylogenetic relationship of hosts of *Podarcis* group in the Iberian Peninsula and the Balearic Islands.

JORGE *et al.* (2011) used molecular methods to show that the different species of lizards of the genus *Gallotia* in the Canary Islands were colonized by two independent *Spauligodon* lineages. This led to the description of two different species of this genus, *S. atlanticus* from the islands of Lanzarote and Fuerteventura and *S. occidentalis* from the western islands (JORGE *et al.*, 2013). Thus, it would be appropriate in this kind of studies to concretize the phylogenetic relationships and the possible co-evolution between Ibero-Balearic nematodes of the genus *Spauligodon* and hosts of *Podarcis* group.

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