Helminths of some lizards of the Iberian Peninsula: bioindicators of the ecology of their hosts

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Abstract

Helminths of some lizards of the Iberian Peninsula: bioindicators of the ecology of their hosts. Parasitological studies carried out for more than three decades have been compared in twelve of the species of lizards that inhabit Iberian Peninsula. The species studied exhibit different ecological strategies in distinct aspects of their way of life. The working hypothesis is that these different ecological characteristics of these hosts will condition the quality and quantity of their helminth communities. Several parameters of host helminth faunas have been compared, such as prevalence, intensity and abundance of infection, and Brillouin diversity index in order to establish similarities and differences between the parasitic communities of the different hosts. Indeed, there are notable differences among the species of saurian analysed. The food habits and the type of habitat occupied by the hosts are the main elements that can influence the conformation of their helminth faunas.

Key words: parasites, lizards, ecology, Iberian Peninsula.

Resumen

Helmintos de algunos lagartos y lagartijas de la península ibérica: bioindicadores de la ecología de sus hospedadores. Se han recopilado y comparado estudios parasitológicos llevados a cabo durante más de tres décadas en doce de las especies de lagartos y lagartijas que habitan la España peninsular. Las especies estudiadas exhiben diferentes estrategias ecológicas en distintos aspectos de su modo de vida. La hipótesis de trabajo es que esas diferentes características ecológicas de estos hospedadores condicionan el establecimiento de distintos tipos o grados de parasitofauna. Se comparan diversos parámetros de las helmintofaunas de los hospedadores, tales como prevalencia, intensidad y abundancia de infección, e índice de diversidad de Brillouin a fin de establecer semejanzas y diferencias entre las comunidades parásitas de los diferentes hospedadores. En efecto, se aprecia cómo hay diferencias notables entre las distintas especies de saurios analizadas en cuanto a su fauna de endohelmintos parásitos. Se señalan principalmente la alimentación y el tipo de hábitat que ocupan los hospedadores como elementos que pueden influir en mayor medida en la conformación de sus faunas de helmintos parásitos.

Palabras clave: parásitos, lacértidos, ecología, península ibérica.

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Introduction

Reptiles are excellent systems to explore patterns and processes influencing helminth community organization because they have invaded a multitude of habitats and exhibit a striking diversity of life history patterns, body sizes, foraging modes, reproductive strategies or trophic relations (Aho, 1990).

On the other hand, parasites play a role as biomarkers of environmental quality (Marcogliese, 2005) but can also be indicative of environmental stress (Megía–Palma *et al*., 2020). Recently, some extrinsic and intrinsic factors have been identified as predictors of prevalence and abundance of ecto and endoparasites in a community of lizards (Drechsler *et al*., 2021).

Since 1990s research on parasitic reptile communities has increased significantly to approach what is known about other birds, mammals or fish hosts (Aho, 1990; Dobson & Pacala, 1992; Galdón *et al*., 2006; Goldberg & Bursey, 1996; Roca & Hornero, 1994; Roca *et al*., 2016), and suggest that reptile helminth communities are poorest than those of mammals, birds or fish (Aho, 1990). Some characteristics of the hosts as ectothermy, simple diet, generalist feeding, or low vagility have been suggested as factors that cause the low diversity of the helminth communities in reptiles (Aho, 1990; Roca & Hornero, 1994), although other environmental factors, as dry or humid habitats, altitude, temperature, can also have influence in the reptile parasite faunas (Roca *et al*., 2016).

The investigations of the parasite communities of the Spanish reptiles have revealed the general patterns for these hosts (Roca & Hornero, 1994). Nevertheless, also have revealed that there are some phenological and environmental factors that can have influence in the helminth communities of different reptile species. Thus, reptiles with tendency to herbivory have more diverse helminth communities than carnivorous ones (Roca, 1999); and some lizards living in humid habitats can be infected by parasites not found in dry areas (Roca *et al*., 1990).

For more than thirty years our research group has studied the helminth communities of many species of lizards of the Iberian Peninsula and Spanish insular territories (Roca, 1999). From the data obtained we now offer a comparison among the different hosts investigated. Specifically, we addressed the following objectives: (i) characterization of the parasitic infection of the host investigated, in terms of prevalence, intensity and abundance of parasitation; (ii) characterization of the richness and diversity patterns of the helminth communities; (iii) comparison among the helminth communities in relation to intrinsic and extrinsic host factors.

Material and methods

Twelve species of lizards (Lacertidae) were helminthologically analysed: *Timon lepidus* (Daudin, 1802) (n=5), *Lacerta bilineata* (Daudin, 1802) (n=1), *Lacerta schreiberi* Bedriaga, 1878 (n=229), *Iberolacerta cyreni* (Müller et Hellmich, 1937) (n=23), *Zootoca vivipara* (Jacquin, 1787) (n=129), *Podarcis muralis* (Laurenti, 1768) (n=276), *Podarcis hispanica* (Steindachner, 1870) (n=188), *Podarcis bocagei* (Seoane, 1884) (n=249), *Podarcis carbonelli* (Pérez–Mellado, 1981) (n=257), *Psammodromus algirus* (Linnaeus, 1758) (n=102), *Psammodromus edwarsianus* (Dugès, 1829) (n=27), *Acanthodactylus erythrurus* (Schinz, 1833) (n=72). The sampling areas are indicated in Figure 1. All the hosts and parasites were processed in accordance with the usual techniques in Parasitology (Galdón, 2007). The use of descriptive ecological terms follows Bush *et al*. (1997). Brillouin's index was used to calculate the diversity according to Magurran (2004).

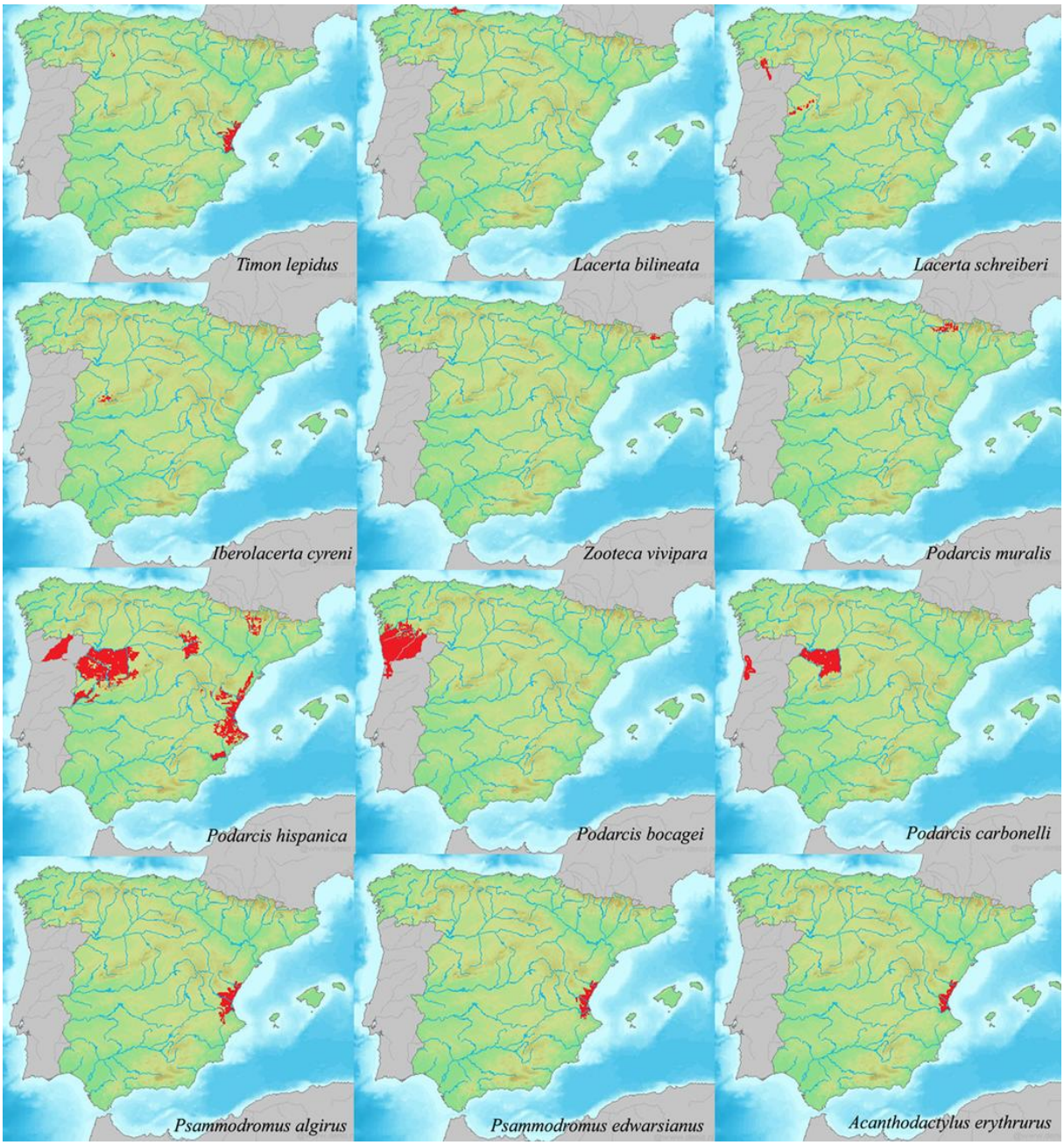

Figure 1. Sampling areas of the 12 species of lizards analysed.
Figura 1. Áreas de muestreo de las 12 especies de lagartos y lagartijas analizados.

Results

Table 1 shows the global prevalence, mean intensity and mean abundance of infection of the hosts and also the Brillouin's diversity index of the helminth communities of each host species. In all, 4 species of Trematoda (1 in larval form), 5 of Cestoda (2 in larval form), and 15 of Nematoda (2 in larval form) were found. Table 2 shows the presence/absence of the helminth species in each lizard species.

HOST	Prevalence (%)	Mean intensity	Mean abundance	Brillouin's index
Timon lepidus	60 (3/5)	102±165 (4–293)	61±130 (0–293)	0
Lacerta bilineata	– –	– –	– –	– –
Lacerta schreiberi	55.0 (126/229)	22±36 (1–243)	13±30 (0–243)	0.1±0.21 (0–0.9)
Iberolacerta cyreni	74.0 (17/23)	2.8±6.2 (1–27)	2.1±5,5 (0–27)	0.03±0.08 (0–0.35)
Podarcis muralis	45.3 (125/276)	12.4±35 (1–273)	5.6±24 (0–273)	0.05±0.15 (0–0.91)
Podarcis hispanica	52.7 (99/188)	11.8±28 (1–195)	6.2±21.3 (0–195)	0.05±0.15 (0–0.81)
Podarcis bocagei	13.7 (34/249)	3.6±4.8 (1–27)	0.25±1.8 (0–27)	0
Podarcis carbonelli	14.0 (36/257)	5.8±6.3 (1–32)	0.3±1.9 (0–32)	0.001±0.02 (0–0.34)
Zootoca vivipara	39.4 (50/129)	1±2.1 (1–10)	0.9±1.8 (0–10)	0.003±0.03 (0–0.04)
Psammodromus algirus	3.0 (3/102)	3.3±4 (1–8)	1.2±2.3 (0–8)	0
Psammodromus edwarsianus	3.7 (1/27)	– –	– –	0
Acanthodactylus erythrurus	34.7 (25/72)	9.4±6.2 (1–15)	4.2±5.1 (0–15)	0

Table 1. Infection parameters and diversity index of the analysed lizards.
Tabla 1. Parámetros de infección e índice de diversidad de los lagartos y lagartijas analizados.

Helminth species	Tl	Lb	Ls	Ic	Zv	Pm	Ph	Pb	Pc	Psa	Pse	Ae
TREMATODA												
Plagiorchis molini			●	●	●	●						
Sonsinotrema tacapense							●					
Pleurogenoides medians							●					
Brachylaima sp. (metacercariae)								●	●			
CESTODA												
Oochoristica agamae						●					●	●
Oochoristica gallica			●				●	●	●			
Nematotaenia tarentolae			●	●			●	●				
Diplopylidium acanthotetra (larvae)										●		
Mesocestoides sp. (larvae)			●			●	●	●			●	
NEMATODA												
Skrjabinodon medinae			●			●	●					
Spauligodon carbonelli			●	●		●	●	●	●			
Spauligodon saxicolae							●			●		
Spauligodon paratectipenis							●					
Spauligodon extenuatus			●									
Parapharyngodon bulbosus	●											
Parapharyngodon echinatus			●				●			●	●	
Parapharyngodon psammodromi											●	
Skrjabinelazia taurica								●				
Skrjabinelazia hoffmanni		●		●		●	●	●	●	●		
Skrjabinelazia pyrenaica						●	●	●				
Abbreviata abbreviata	●		●									
Oswaldocruzia filiformis					●	●						
Acuaria sp. (larvae)	●						●					
Spirurida gen. sp. *(larvae)*								●				●

Table 2. Presence–absence of the helminth species in the analysed lizards. (Abbreviations: Tl:*Timon Lepidus;* Lb:*Lacerta bilineata*; Ls:*Lacerta schreiberi*; Ic:*Iberolacerta cyreni*; Zv:*Zootoca vivipara*: Pm;*Podarcis muralis* Ph:*Podarcis hispanica*; Pb:*Podarcis bocagei*; Pc:*Podarcis carbonelli;* Psa:*Psammodromus algirus*; Pse:*Psammodromus edwarsianus*; Ae:*Acanthodactylus erythrurus*).
Tabla 2. Presencia–ausencia de especie de helmintos en los lagartos y lagartijas analizadas. (Abreviaturas: Tl:Timon lepidus; *Lb*:Lacerta bilineata; *Ls*:Lacerta schreiberi; *Ic*:Iberolacerta cyreni; *Zv*:Zootoca vivipara: *Pm*:Podarcis muralis; *Ph*:Podarcis hispanica; *Pb*:Podarcis bocagei; *Pc*:Podarcis carbonelli; *Psa*:Psammodromus algirus; *Pse*:Psammodromus edwarsianus; *Ae*:Acanthodactylus erythrurus*).*

Discussion

The very low diversity index found in all the searched host species and also the presence of Pharyngodonidae nematodes typical of carnivorous reptiles (Roca, 1999) suggest insectivorous feeding habits for these peninsular lacertid lizards if compared with another similar lizards as *Podarcis pityusensis* and *Podarcis lilfordi* (Roca & Hornero, 1994) both insular species that exhibit a certain degree of herbivory (Pérez–Mellado & Corti, 1993; Brown & Pérez–Mellado, 1994) concomitant with a higher index of helminth diversity. Other reptiles as the endemic Canarian lizards or some tortoises (*Testudo* spp.) (Roca, 1999) show very higher values of helminth diversity and also include in their helminth communities species of nematodes typical of herbivorous reptiles (Petter, 1966). The presence of adult cestodes (*Oochoristica* spp., *Nematotaenia tarentolae* López–Neyra, 1944) and nematodes (*Skrabinelazia* spp., *Abbreviata abbreviate* Rudolphi, 1819, *Oswalducruzia filiformis* Goeze, 1782) with indirect life cycles that include an arthropod as intermediate host, reinforces the evidence of the insectivorous feeding habits of the searched hosts.

On the other hand, the presence of cestodes (*Mesocestoides* sp., *Diplopylidium acanthotetra* Parona, 1886) and nematodes (*Acuaria* sp., *Spirurida* gen. sp.) as larval stage whose adult forms develop in mammals or birds, suggests that most of lizards may be prey of these definitive hosts.

The species living in humid areas as *Lacerta schreiberi* or *Podarcis muralis*, tend to reach higher values of richness and abundance of helminth species than those that occupy drier environments, as *Psammodromus algirus*, *Ps. hispanicus* and *Acanthodactylus erythrurus*. The digenids, with mixed aquatic-terrestrial life cycles that include freshwater molluscs, are indicators of the type of habitat were the lizards that host them live. Thus, excepting *Brachylaima* sp. that is an accidental parasite of *Podarcis bocagei* and *P. carbonelli* (Roca *et al*., 2006), the Eurasiatic trematode species *Plagiorchis molini* has been found in Iberian lizards linked to humid environments of the north of the Iberian Peninsula, whereas the Mediterranean trematode species *Sonsinotrema tacapense* and *Pleurogenoides medians* have been recorded in populations of *Podarcis hispanica* living in coastal marshes (see Table 2). No trematodes have been found in lizard populations and species living in dry habitats as *Psammodromus* spp. and *A. erythrurus*. The habitat and the climate conditions as extrinsic factors predicting the type and the parasitic burden in these hosts (Drechsler *et al.*, 2021).

Among the intrinsic factors that condition the helminthfauna of these hosts, age and body size are the most important. Thus, the lizards *T. lepidus* and *L. schreiberi* exhibit the highest intensities and abundances of infection whereas small species such as *Z. vivipara* or *P. edwarsianus* show very low values. The relationship between parasite infection with the host size (evidenced when sample size is sufficient), it seems to be just an indicator of lizard age and, hence, of time for parasite recruitment (Roca *et al*., 2006). Fitze (2012) points for example to the case of *P. edwarsianus* that the low values of parasitation suggest a connection between age and the probability of infection since this lizard has a very short life cycle with almost 100% annual renewal of its populations.

In general conclusion, the depauperate helminth communities found in the Iberian lizards are better explained by their biotic and abiotic characteristics (see above) that includes low number of interactions with other reptile species, low prey availability, and low opportunities for parasitic recruitment (Roca *et al*., 2020). All these features may modify the possibilities of lizard hosts for recruiting parasites.

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