Basic and Applied Herpetology 31 (2017) 69-75

Helminth parasitizing *Iberolacerta cyreni* (Müller et Hellmich, 1937) from Gredos Mountains, Iberian Peninsula

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Received: 19 September 2017; returned for review: 16 October 2017; accepted 3 November 2017.

A survey of the helminth communities of a population of *Iberolacerta cyreni* (Müller et Hellmich, 1937), a small lizard endemic to Sistema Central (Iberian Peninsula), was conducted to determine the prevalence, abundance and species diversity of parasites of these reptiles. Four species of helminths were found, one trematode, *Plagiorchis molini* Lent et Freitas, 1940, one cestode, *Nematotaenia tarentolae* López-Neyra, 1944, and two nematodes, *Skrjabinelazia* sp. and *Spauligodon carbonelli* Roca & García-Adell, 1988. Helminth infracommunities of *I. cireny* showed very low values of abundance and species richness and diversity, being similar to other European lizards. The parasites found seem to have no influence on the conservation status of the host species in its natural habitat.

Key words: conservation; helminths; Iberian Peninsula; lizards.

Iberolacerta cyreni (Müller *et* Hellmich, 1937) is an endemic lacertid lizard from Gredos and Guadarrama Mountains in Central-West and Central Iberian Peninsula (Carretero *et al*., 2014). Morphological characteristics, structure of chromosomes, and electrophoretic data (Arribas, 1996), as well as recent data from mitochondrial and nuclear DNA confirm the specific status of the lizard populations from this geographical area (Martín, 2009). It seems that the origin of this lizard (prior to the Pleistocene glacial oscillation) was favoured by the complex orography of these mountains, acting as speciation cores and refuge of the species (Crochet *et al*., 2004).

These lizards are typically linked to high mountain rocks. They are generalist feeders eating many insects and other arthropods. They use both sit-and-wait, and active foraging strategies (Martín & Salvador, 1993).

Iberolacerta cyreni is considered as a threatened species (Pérez-Mellado *et al*., 2009). The destruction of its high mountain habitats, and the vulnerable nature of certain populations derived from the isolation regime among each other, are the main threats (Martín, 2009).

Concerning parasites, haemogregarines have been found infecting erythrocytes from lizard populations in Guadarrama

DOI: http://dx.doi.org/10.11160/bah.89 Supplementary material available online

(AMO *et al*., 2004; JOVANI *et al*., 2004), but there is no data on parasitic helminths of any population of this species.

As lizards living in high-altitude habitats, we would expect a poor helminth community for *I. cyreni*. However, there are not conclusive results regarding the influence of altitude in relation to the parasite infection in reptiles. For instance, MAIA *et al.* (2016) found a negative correlation between prevalence and altitude in *Pristurus rupestris* (Gekkonidae) from Oman, Arabia. Low richness of the helminth community has also been recorded from a population of *Mabuya dorsivittata* (Scincidae) in Itatiaia, a high-altitude habitat in Rio de Janeiro State (ROCHA *et al*., 2003). Nevertheless, populations of *Sceloporus occidentalis* (Iguanidae) from San Gabriel Mountains (montane, ca. 1584 m elevation, Los Angeles, California) showed greater prevalence of infection of gastrointestinal nematodes than populations from Puente Hills (lowland, ca. 150 m elevation) (GOLDBERG *et al*., 1998). Additionally, it seems that digestive parasite nematodes do not play a major role in setting altitudinal distribution limits for *Liolaemus* lizards in the central Chilean cordillera (CAROTHERS & JAKSIC, 2001).

Hence, the objective of this study was to investigate for the first time the helminth fauna of the host species *I. cyreni*. More specifically, this study aimed: (1) to know what kind of helminths parasitize this lizard; (2) to determine the patterns of helminth community richness and diversity; (3) to compare these patterns with those already described for other allied lizards; (4) to take into account the parasites among the issues to be considered for the conservation of the host species.

MATERIALS AND METHODS

Study Area

The area of the study, Sierra de Gredos (40° 15′ N, 5° 13′ O), are a group of mountains belonging to the Sistema Central, located at the West-Centre of the Iberian Peninsula. It consists of granitic rocks and a variety of vegetation cover, changing according to the altitude, with a typical high mountain climate (DELGADO-SÁNCHEZ, 1996).

Host samples

Samples correspond to 23 specimens of *I. cyreni* stored in the collection of the Laboratory of Animal Parasitology of the Department of Zoology, University of Valencia (Spain) (see collection numbers in the Supplementary Material, Section S1). The specimens were caught in the Sierra de Gredos in the years 1985 (four hosts), 1986 (six hosts), 1987 (six hosts) and 1988 (seven hosts), and the samples were sent to our laboratory, following the necropsy of dead hosts. The digestive tract, heart, lungs, and liver were removed, opened, and placed in Ringer solution for examination.

Analysis of parasites

The parasites were preserved in 70% alcohol and are deposited in the collection of the Laboratory of Animal Parasitology, Department of Zoology of the University of Valencia (Spain) (see collection numbers in the Supplementary Material, Section S2). Now they have been studied according to standard techniques (HORNERO, 1991). Parasites were identified, when possible, to the species level and the number

Table 1: Parameters of infection of helminths in *Iberolacerta cyreni*.

Helminth species	Prevalence (%)	Intensity of infection (range)	Abundance (range)
Trematoda			
Plagiorchis molini	9	1.5 ± 0.7 (1 – 2)	0.1 ± 0.5 (0 – 2)
Cestoda			
Nematotaenia tarentolae	13	1 ± 0 (1 – 1)	0.1 ± 0.3 (0 – 1)
Nematoda			
Skrjabinelazia sp.	9	1 ± 0 (1 – 1)	0.1 ± 0.3 (0 – 1)
Spauligodon carbonelli	52	3.3 ± 6.9 (1 – 25)	1.7 ± 5.1 (0 – 25)

and location of individual parasites of each species per host were recorded. Diversity and infection parameters described in BUSH *et al*. (1997) were used to define the ecology of the parasites. Thus, prevalence is defined as the number of hosts parasitized divided by the total number of hosts sampled; mean intensity, as the total number of helminths divided by the number of infected hosts; mean abundance, as the total number of worms divided by the total number of hosts sampled. Brillouin's index was used for calculating diversity, according to MAGURRAN (2004).

RESULTS

The host *I. cyreni* was infected with four species of helminths (one trematode, one cestode and two nematodes, see Table 1). All the helminths were found in the digestive tract; the nematode *Skrjabinelazia* sp. in the stomach, the trematode *Plagiorchis molini* and the cestode *Nematotaenia tarentolae* in the small intestine and the nematode *Spauligodon carbonelli* (but see discussion) in the large intestine. Of the species found, *S. carbonelli* was the most common, with 52% of all hosts infected. Detailed infection parameters for individual species of parasite are given in Table 1. The average number of parasite species per lizard was 0.8 ± 0.6 (0 – 2) and the maximum number of parasite taxa found in any individual lizard never exceeded two. The helminths encountered had a global prevalence (all taxa) of 74% (17/23). While the mean intensity of infection (all taxa) was 2.8 ± 6.2 (1 – 27), the mean abundance (all taxa) was 2.1 ± 5.5 (0 – 27). The value of Brillouin's index diversity was 0.03 ± 0.08 (0 – 0.35). Proportion of hosts with 0 or 1 helminth species was 91%.

DISCUSSION

The trematode *P. molini*, which is mainly characterized by the extension of the vitellaria (ROCA & NAVARRO, 1983), was previously found in Iberian Peninsula parasitizing different species of lizards, such as *Podarcis muralis*, *Lacerta schreiberi* or *Zootoca vivipara*, all of them living in high mountains and linked to humid environments (GARCÍA-ADELL & ROCA, 1988; ROCA & FERRAGUT, 1989; SANCHIS *et al*., 2000), which are adequate for the development of the life cycle of this parasite. So, it is not surprising the finding of this trematode in the lizard *I. cireny*, as this host shares the ecologi-

Host species	Geographical distribution	Brillouin's index	Reference
	Iberian Peninsula		
Iberolacerta cyreni	Gredos	0.03	Present study
Podarcis bocagei	NW Portugal	0	GALDÓN *et al*., 2006
Podarcis carbonelli	NW Portugal	0.001	GALDÓN *et al*., 2006
Zootoca vivipara	Pyrenees	0.003	SANCHIS *et al*., 2000
	Caucasian		
Darevskia rudis	NE Anatolia	0.01	ROCA *et al*., 2016a
Darevskia parvula	NE Anatolia	0.01	ROCA *et al*., 2016b
Other *Darevskia* spp.	NE Anatolia	0	ROCA *et al*., 2016b

Table 2: Comparison of values of Brillouin's index of diversity of several continental European lacertid lizards.

cal characteristics with those other hosts quoted (MARTÍN, 2009).

The cestode *N. tarentolae* is a species with a wider range of distribution, which has been previously found in several lizard hosts in different ecological conditions, including habitats of high mountains (GARCÍA-ADELL & ROCA, 1988; ROCA & FERRAGUT, 1989).

As only females were found, the specimens of *Skrjabinelazia* were not exactly identified to the species level. They probably belong to *S. hoffmanni*, a species usually found parasitizing other lizards in this area (ROCA *et al*., 1990).

The other nematode found was firstly identified as *Skrjabinodon medinae*, according to the morphological characteristics of males and females (HORNERO & ROCA, 1992). Nevertheless, recently JORGE *et al*. (2014) suggested that in parasitic nematodes of the genus *Spauligodon* there is a "major male form", which exhibits the traditional male morphological traits reported for this taxon, coexisting with a "minor morph" with reduced morphological traits resembling more closely the males of the sister genus *Skrjabinodon* than *Spauligodon* major males. *Spauligodon carbonelli* is one of the species with "major" and "minor" forms (JORGE *et al*., 2014). It usually infects lacertid lizards sympatric with *I. cyreni*, such as *Podarcis hispanica*, *P. bocagei* and *P. carbonelli* (GALDÓN *et al*., 2006). So, it is probable that males found here belong to the species *S. carbonelli*.

The most common helminth in the community of *I. cyreni* is the pharyngodonid nematode *S. carbonelli*, which should be considered as a rock lizard specialist (ROCA & HORNERO, 1994), since it has been recorded for this group of lizards (GALDÓN *et al*., 2006). The remaining helminth species have been recorded from several other lizard genera, so they appear to be generalists.

Most helminth species found in *I. cyreni* occurred at low prevalence and intensity. Only *S. carbonelli* can be considered as a core species (ROCA & HORNERO, 1992); *N. taren-*

tolae is a secondary species and *S. hoffmanni* and *P. molini* are satellite species at the component community level.

The low average number of parasite species per lizard, as well as the low values of Brillouin's index, emphasizes the very low diversity of the helminth infracommunities of *I. cyrreni*. This agrees with the typical pattern of helminth infection in many lizards (ROCA *et al*., 2016a). Nevertheless, the helminth community of *I. cyreni* seems less depauperate than helminth communities found in other continental carnivorous lizards in Iberian Peninsula, or in the Caucasus (Table 2). Probably some ecological factors (i.e. high number of interactions with other reptile species) occurring in the habitats occupied by *I. cyreni*, allow major opportunities for parasite recruitment.

ROCHA *et al*. (2003) and MAIA *et al*. (2016) found a negative correlation between parasite infection and altitude. ROCHA *et al*. (2003) suggested that depauperate helminth communities in *M. dorsivittata* may be a result of the relative isolation (insularity effect) of the study area. Our results, not only corroborate a possible negative correlation between parasite infection and altitude, but also suggest that the habitats occupied by *I. cyreni* in Sierra de Gredos are also useful for many other species which can act as intermediate hosts in the life cycle of its parasites, and also let the development of the parasites with direct life cycles.

Although parasites can affect the health of the host, thereby undermining the balance of the host-parasite relationship (MARCOGLIESE, 2004), studies on the conservation of various species of lizards (ROCA *et al*., 1999; ROCA, 2002) have evidenced that these hosts coexist in equilibrium with their parasitic helminths (ROCA & CARBONELL, 1993), and that these parasites are not a potential cause of a decline or eventual extinction of any population of those lizards (ROCA *et al*., 1999). The pattern of the helminth community of *I. cyreni* (helminth species and low parameters of infection) suggest that, as in the cases mentioned above, parasites should not be a problem for the survival of the host species in its current habitats and environmental conditions.

Bioethical Considerations

The author has followed the corresponding legislation on animal care.

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