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Research Note

Intestinal parasites of unisexual and bisexual lizards *Darevskia* spp. (Lacertidae) from Northeastern Anatolia

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Summary

Four bisexual and two unisexual species of the lizard genus *Darevskia* from northeastern Anatolia were searched for intestinal parasites in adult specimens. One cestode, *Nematotaenia tarentolae*, and two nematode species, *Spauligodon saxicolae* and *Strongyloides darevskyi*, were found, the latest identified as a *Darevskia* specialist. No major differences between host species were recorded. The very low infection rates and diversity result in depauperate helminth communities for all these lacertid lizards being the lowest among the Palaearctic saurians. Patterns of these helminth communities are compared with those observed in other lacertid lizards from Anatolia and Europe.
Keywords: parasites; Caucasian rock lizards; parthenogens; Turkey

Introduction

Caucasian rock lizards (*Darevskia* spp.) are small saurians of the family Lacertidae ranging from western Asia and south-eastern Europe (Ananjeva *et al*., 2006; Arnold *et al*., 2007). Although they are ecologically similar to the European rock lizards they include not only bisexual species but also parthenogenetic forms (Darevsky, 1978; Tarkhvishnili, 2012).

Parasitological knowledge of the parasites of the Caucasian rock lizards is still fragmentary with only a few recent studies investigating the parasite communities in deep. In particular no helminthological data are known for many species whereas data are partial and scarce for others, focusing mainly on taxonomy and faunistic studies (Schad *et al*., 1960; Markov & Bodganov, 1962; Sharpilo, 1962, 1976; Saygi, 1993). Recently some studies have paid attention on helminths of several species of *Darevskia* from Armenia (Sargsyan & Harutyunyan, 2012; Sargsyan, 2013; Sargsyan *et al*., 2013). Even more recently, Roca *et al*. (2015, 2016) analysed the helminth communities in unisexual endemic lizards from Turkey and the structure of helminth community of *D*. *rudis* across northern Anatolia. Studies available on these Turkish species conclude that, as in other Palaearctic lacertid lizards, their helminth communities are poor and isolationist (Roca & Hornero, 1994; Galdón *et al*., 2006), although Roca *et al*. (2016) pointed out that *D*. *rudis* had richer diversity than other continental Palaearctic rock lizards such as *Podarcis hispanica*, *Podarcis muralis*, *Podarcis bocagei* or *Podarcis carbonelli*.

In this study, we encompass a parasitological analysis of several species of *Darevskia* from Turkey whose helminthfauna is unknown. Specifically we addressed the following objectives: (i) characterization richness and diversity patterns of the helminth communities; (ii) characterization of the helminth species parasitizing the host as either specialists or generalists; and (iii) comparison of the helminth communities with those of other *Darevskia* hosts, and other Palaearctic rock lizards.

Materials and Methods

Four bisexual and two unisexual species of the genus *Darevskia* (Table 1), all belonging to the herpetological collection of the Fauna and Flora Research and Application Center, Dokuz Eylul

Table 1. Sampled localities (provinces) of the host populations of *Darevskia* spp.

Species	Condition	N° of specimens	Locality, province	Coordinates latitude (°N), longitude (°W)	Altitude (m)
D. clarkorum	bisexual	13	between Borçka and Hopa 8 km, Artvin	41°22’37”, 41°33’40”	471
D. clarkorum	bisexual	16	between Çamlıhemşin and Ayder Plateau 3 km, Rize	41°02’44”, 41°01’40”	370
D. parvula	bisexual	48	Şavşat, Artvin	41°15’32”, 42°19’45”	1893
D. raddei	bisexual	10	Hoşap Güzelsu, Van	38°25’45”, 43°24’38”	2002
D. raddei	bisexual	6	between Van and Özalp 47 km, Van	38°39’41”, 43°50’08”	1915
D. raddei	bisexual	10	Muradiye (Bendimahi waterfall), Van	39°03’24”, 43°45’25”	1902
D. valentini	bisexual	24	between Göle and Susuz 17 km, Ardahan	40°51’17’, 42°48’04”	2086
D. armeniaca	parthenogenetic	28	between Ardahan and Göle 10 km, Ardahan	41°06’54”, 42°42’31”	1785
D. unisexualis	parthenogenetic	11	Horasan, Agri	39°53’14”, 42°21’36”	1995

University (Turkey), were examined (see addendum for accession numbers). Populations were sampled in July 2010 from northeastern and eastern Anatolia, with altitude levels ranging from 1370 to 2086 m a.s.l. In this region, climate changes from Oceanic in the Black Sea coast to Continental in Eastern Anatolia due to abrupt increase in thermal amplitude and aridification (Sensoy *et al*., 2008).

Lizards were dissected for parasitological examination. This method still ensures a much better detection and quantification of intestinal parasites with a few specimens than some non-invasive techniques (Jorge *et al*., 2013). Helminths were processed in accordance with the usual techniques in parasitology (Hornero, 1991). The parasite vouchers were deposited in the parasitological collection of the Department of Zoology of University of Valencia, Spain, with the species name accompanied by the host code (see addendum for accession numbers).

The use of descriptive ecological terms follows Bush *et al*. (1997). Brillouin’s index was used for calculating diversity according to Magurran (2004). Criteria of Edwards & Bush (1989) and Roca & Hornero (1994) were used in the consideration of the helminth species as specialists or generalists.

Results

Only three helminth species were found, the cestode *Nematotaenia tarentolae* and the nematodes *Spauligodon saxicolae* and *Strongyloides darevskyi*. Table 2 shows the global prevalence, intensity and abundance of infection of the hosts. Table 3 shows the

Table 2. Infection parameters of the analysed lizard hosts

Host	n	Prevalence (%)	Intensity* of infection	Abundance* of infection
D. clarkorum	29 (13♂, 16♀)	13.8	2.3 ± 1.9 (1 – 5)	0.3 ± 1.0 (0 – 5)
D. parvula	48 (21♂, 27♀)	22.9	2.1 ± 1.3 (1 – 5)	0.5 ± 1.1 (0 – 5)
D. raddei	26 (17♂, 9♀)	11.5	2.0 ± 1.0 (1 – 3)	0.2 ± 0.7 (0 – 3)
D. valentini	24 (15♂, 9♀)	20.8	2.2 ± 2.2 (1 – 6)	0.5 ± 1.3 (0 – 6)
D. armeniaca	28 (♀)	3.6	–	0.1 ± 0.4 (0 – 2)
D. unisexualis	11(♀)	18.2	1.0 ± 0.0 (1 – 1)	0.2 ± 0.4 (0 – 1)

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

Table 3. Overall diversity parameters of the helminth infracommunities of analysed lizard hosts

Host	Species richness	Species abundance	Brillouin's index
D. clarkorum	0.14 ± 0.35 (0 – 1)	0.31 ± 1.0 (0 – 5)	0
D. parvula	0.25 ± 0.48 (0 – 2)	0.48 ± 1.07 (0 – 5)	0.01 ± 0.07(0 – 0.46)
D. raddei	0.12 ± 0.33 (0 – 1)	0.23 ± 0.71 (0 – 3)	0
D. valentini	0.21 ± 0.41 (0 – 1)	0.50 ± 1.35 (0 – 6)	0
D. armeniaca	0.04 ± 0.19 (0 – 1)	0.07 ± 0.38 (0 – 2)	0
D. unisexualis	0.18 ± 0.40 (0 – 1)	0.18 ± 0.40 (0 – 1)	0

species richness and abundance in the helminth infracommunities of each host species. The presence of helminths found, and their infection parameters are shown in Table 4.

N. tarentolae and *S. darevskyi* occupied the small intestine whereas *S. saxicolae* was found in the rectum. *S. saxicolae* was found in all host species analysed except in *D. armeniaca*, and, thus, it was the main or the only component of their irrespective helminth infracommunities. *N. tarentolae* was found in *D. parvula* and *D. valentini*, and *S. darevskyi* was only recorded in *D. armeniaca*.

Discussion

All the helminths found in the *Darevskia* lizards studied are common in reptiles from the South and South East Europe and the west of the former USSR (Schad *et al*., 1960; Markov & Bogdanov, 1962; Sharpilo, 1976; Saygi, 1993; Roca *et al*., 2015, 2016).

The most common helminth in the communities of the analysed hosts is the pharyngodonyd nematode *Spauligodon saxicolae* (found under two morphotypes, see Jorge *et al*., 2014; Roca *et al*., 2016) which should be considered as rock lizards specialist (*sensu* Edwards & Bush [1989], but also see Roca & Hornero [1994]), since it has been recorded from *Darevskia* and *Podarcis* lizard species (Sharpilo, 1976; Roca *et al*. 1986); *Strongyloides darevskyi* is in fact a true *Darevskia* specialist since it has been recorded only from species of this genus (Roca *et al*., 2016). The cestode *N. tarentolae* is a generalist species found in many different lizard genera (Roca *et al*., 1985).

Apart from *S. saxicolae* no other pharyngodonid were found in any

Table 4. Values of infection parameters of the found parasites in the analysed lizard hosts. ẋi = mean intensity; ẋa = mean abundance

Host	*N. tarentolae*	*S. saxicolae*	*S. darevskyi*
D. clarkorum		P = 13.8 % ẋi = 2.3 ± 1.9 (1 – 5) ẋa = 0.3 ± 1 (0 – 5)	
D. parvula	P = 4.2 % ẋi = 1.5 ± 0.7 (1 – 2) ẋa = 0.7 ± 0.3 (0 – 2)	P = 20.8 % ẋi = 2 ± 1.5 (1 – 4) ẋa = 0.4 ± 1 (0 – 4)	
D. raddei		P = 11.6 % ẋi = 2 ± 1 (1 – 3) ẋa = 0.2 ± 0.7 (0 – 3)	
D. valentini	P = 4.2 % ẋi = – ẋa = –	P = 16.7 % ẋi = 2.8 ± 2.4 (1 – 6) ẋa = 0.5 ± 1.4(0 – 6)	
D. armeniaca			P = 3.6 % ẋi = – ẋa = –
D. unisexualis		P = 18.2 % ẋi = 1 ± 0 (1 – 1) ẋa = 0.2 ± 0.4 (0 – 1)	

Addendum

Accesion numbers of the searched hosts

D. clarkorum: DC1A – DC1M; DC2A; DC2C – DC2H; DC2J – DC2P; DC2S – DC2T

D. parvula: DP1A – DP1K; DP1M – DP1Z; DP2A – DP2H; DP2J – DP2K; DP3A – DP3F; DP3H – DP3O; DP3R

D. raddei: DAR1A – DAR1J; DAR2B; DAR2D – DAR2G; DAR3A – DAR3J

D. valentini: DV1 –DV24

D. armeniaca: DA1A – DA1P; DA2A – DA2F; DA2H – DA2M

D. unisexualis: DUX1 – DUX9; DUX11 – DUX12

Accesion numbers of the parasites

N. tarentolae: DP1E.Nt; DP1J.Nt; DV18.Nt

S. saxicolae: DC2C.Sk; DC1B.Sk; DC1D.Sk; DC2M.Sk; DUX4.Sk; DUX9.Sk; DP1H.Ss; DP1J.Ss; DP1O.Ss; DP1R.Ss; DP1V.Ss; DP2G.Ss; DP3F.Ss; DP3J.Ss; DP3M.Ss; DP3O.Ss; DAR1J.Ss; DAR3E.Ss; DAR3J.Ss; DV6.Ss; DV8.Ss; DV11.Ss

S. darevskyi: DA1A.Sd

of the searched hosts. This deviates from the usual pattern found in different European lacertid lizards, in which other *Spauligodon* species frequently share reptile hosts with members of the genera *Skrjabinodon* (but see Jorge *et al*., 2014) and *Parapharyngodon* (García-Adell & Roca, 1988; Roca *et al*., 1986, 2009; Roca & Hornero, 1994). This contributes to the simple helminth communities found in the studied lizards, as evidenced by the low values of helminth richness, abundance, and diversity (Table 3).

Although depauperate and isolationist helminth communities are common in reptiles (Aho, 1990; Roca & Hornero, 1994), the *Darevskia* spp. analysed here show the lowest diverse helminth communities within the Palaearctic lacertid lizards. Our results for the two parthenogenetic species are in accordance with those obtained by Roca *et al*. (2015), who found the extremely poor helminth communities in the also parthenogenetic *Darevskia uzzelli* and *D. bendimahiensis*, when compared with their sexual relatives. Similar patterns have also been recorded for the teiid lizards genus *Aspidocelis* in North America (i.e. McAllister, 1990). Accordingly, in our study, the unisexual *D. armeniaca* shows the lowest values of helminth species richness and abundance, and the other parthenogenetic form, *D. unisexualis*, shows lower helminth abundance comparing to the bisexual forms and one of the lowest values of the helminth richness. Nevertheless, the very low values of species richness, abundance and diversity also appeared in the bisexual forms analysed, prevents to infer more general trends on the separation of unisexual and bisexual *Darevskia* spp. in relation to their helminthfauna. These very poor helminth communities probably are better explained by some biotic characteristics of the hosts, such as the small body size and a low number of interactions with other vertebrates acting as predators or alternative hosts. Moreover, abiotic characteristics, such as climate and vegetation, may also modify the possibilities of lizard hosts for recruiting parasites (Roca *et al*., 2015). Finally, differences in susceptibility between sexual and asexual lizards have been invoked to explain differences in parasite rates (Moritz *et al*., 1991). However, Hanley *et al.* (1995) argued that other factors than host reproductive mode, such as transmission rates (Anderson & May, 1982) or parasite virulence are important in determining patterns of parasitism. Global prevalence of infection of all the searched hosts (Table 2), both unisexual and bisexual, were lower than those found in the bisexual *D. rudis* across northern Anatolia (Roca *et al*., 2016), and also were lower for the values of species richness, abundance and diversity. The small range and number of *Darevskia* populations analysed here likely provided less diversity of environments and recruitment opportunities, rather than intrinsic specific differences, which results in poorer helminth communities than those harboured by *D. rudis*, a host species with much wider geographical distribution and ecological valence (Roca *et al*., 2016).

Also all the searched hosts show poorer helminth communities and lower prevalence of infection than other continental Palaearctic rock lizards of the genus *Podarcis*. As suggested by Roca (2015), probably it might be better explained by the ecological characteristics of hosts and environment than in terms of the phylogeny of the lizard hosts.

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