

ARE THE HELMINTH COMMUNITIES FROM UNISEXUAL AND BISEXUAL LIZARDS DIFFERENT? EVIDENCE FROM GASTROINTESTINAL PARASITES OF *DAREVSKIA* SPP. IN TURKEY

VICENTE ROCA^{1,2}, FÁTIMA JORGE^{2,3}, ÇETIN İLGAZ⁴, YUSUF KUMLUTAŞ⁴
SALIH HAKAN DURMUŞ⁵ and MIGUEL A. CARRETERO²

¹Departament de Zoologia, Facultat de Ciències Biològiques, Universitat de València
Dr. Moliner, 50, 46100 Burjassot, Spain; E-mail: vicente.roca@uv.es

²CIBIO Research Centre in Biodiversity and Genetic Resources, InBIO
Universidade do Porto, Campus Agrário de Vairão, Rua Padre Armando Quintas, 7.
4485–661 Vairão, Vila do Conde, Portugal; E-mail: carretero@cibio.up.pt

³Departamento de Biologia, Faculdade de Ciências da Universidade do Porto
R. Campo Alegre, s/n, 4169–007 Porto, Portugal; E-mail: fatima.esperanca@cibio.up.pt

⁴Department of Biology, Faculty of Science, Dokuz Eylül University, Buca, İzmir, Turkey
E-mails: cetin.ilgaz@deu.edu.tr, yusuf.kumlutas@deu.edu.tr

⁵Department of Biology, Faculty of Education, Dokuz Eylül University, Buca, Izmir, Turkey
E-mail: salih.durmus@deu.edu.tr

Specimens of three species of parthenogenetic lizards (*Darevskia uzzelli*, *D. bendimahiensis*, and *D. sapphirina*) from northeastern Turkey were examined for gastrointestinal parasites. Only one species, the nematode *Spauligodon saxicolae* (Pharyngodonidae), was found. The extremely low infection and diversity parameters, falling among the lowest within the Palearctic saurians, support depauperate helminth communities for these parthenogenetic lacertid lizards. Our results suggest that parthenogenetic *Darevskia* follow a pattern of parasitism similar to other unisexual lizards (i.e. *Aspidocelis*). The low rates of infection and diversity may be explained by the decreasing opportunities for interchanging helminths rather than factors of susceptibility of unisexual hosts.

Key words: parasites, parthenogenetic lizards, *Darevskia*, Turkey.

INTRODUCTION

Caucasian rock lacertid lizards (*Darevskia* spp.) are small saurians from western Asia and south-eastern Europe. They are similar to the European rock lizards, and they include both bisexual and parthenogenetic species (ARNOLD *et al.* 2007, TARKHVIŠHNILI 2012). Among the unisexual forms, *Darevskia uzzelli* (Darevsky et Daniellyan, 1977), *D. bendimahiensis* (Schmidtler, Eiselt et Darevsky, 1994), and *D. sapphirina* (Schmidtler, Eiselt et Darevsky, 1994) are endemic to northeastern Turkey (SCHMIDTLER *et al.* 1994, BARAN & ATATÜR 1998, BARAN *et al.* 2012). On the basis of genetic markers, all three parthenogenetic forms are believed to have originated by separate hybridization events between the bisexual Valentin's lizard, *D. valentini* (Boettger, 1892) (paternal parent), and Radde's lizard, *D. raddei* (Boettger, 1892) (maternal parent) (Fu

et al. 2000, MURPHY *et al.* 2000). *D. bendimahiensis* has been recorded from few localities from eastern Anatolia and it is listed as endangered because its extent of occurrence is less than 5000 km² (KASKA *et al.* 2009b). *D. uzzelli* and *D. sapphirina* are even more endangered species because they are rarest and narrower distributed species restricted only to small areas from eastern Turkey (AKARSU *et al.* 2009, KASKA *et al.* 2009a).

Several studies on both bisexual and unisexual Caucasian rock lizards have paid attention on morphology, taxonomy, ecology, phylogeny, reproductive traits or distribution of these saurians (MORITZ *et al.* 1992, SCHMIDTLER *et al.* 1994, FU *et al.* 1995, 1997, MACCULLOCK *et al.* 2000, MURPHY *et al.* 2000, ARNOLD *et al.* 2007, DANIELYAN *et al.* 2008, TARKHVISHNILI 2012). Nevertheless much less attention has been paid to their parasites, and thus no helminthological data are known for most of the *Darevskia* species while known data for some of them are partial and scarce, focusing mainly on taxonomy and faunistics (SCHAD *et al.* 1960, MARKOV & BODGANOV 1962, SHARPILO 1962, 1976, SAYGI 1993).

One version of the Red Queen hypothesis (VAN VALEN 1973) suggests that selective pressure from parasites is strongest on the most common genotype in a population, and thus genetically identical clonal lineages with low genetic variability are expected to be more vulnerable to parasitism over time than genetically diverse sexual lineages. Sexual reproduction is maintained in populations because of the need to continually create genotypes that confer resistance against parasites (HAMILTON *et al.* 1990, LADLE 1992). Among reptiles, some studies on ecto- and endoparasites have rendered conflicting results regarding this hypothesis. MORITZ *et al.* (1991) reported that parthenogenetic individuals of the *Heteronotia binoei* species complex (Australian geckos) were much more prone to infection by haematophagous mites than were their sexual relatives. Contrarily, HANLEY *et al.* (1995) reported lower mite infections in parthenogenetic *Lepidodactylus* (Pacific Island geckos) compared with their sexual ancestors; and MENEZES *et al.* (2004) pointed out the low infection rates by helminths of *Ameivula nativo* contrasting with the high values exhibited by the closely related bisexual congener *A. littoralis* in southeastern Brazil.

Most helminthological data on parthenogenetic lizards are known from teiid species, namely the whiptail lizards of the New World genus *Aspidocelis* (former *Cnemidophorus*) from North and Central America. Within the 41 species of *Aspidocelis*, numerous unisexual taxa are common inhabitants of the desert areas of the southwestern United States and adjacent Mexico (MCALLISTER 1992). MCALLISTER (1990a,b,c), MCALLISTER *et al.* (1986, 1991a,b,c) studies, show poor helminth communities on several species of these parthenogenetic lizards and evidence that, the species of *Aspidocelis* usually share parasites, regardless of geographic location or even ancestry (MCALLISTER 1992).

Table 1. Collecting localities of the lizard hosts.

Species	Site	Latitude	Longitude	Altitude (m)	Habitat
<i>D. uzzelli</i>	Horasan	39.936667	42.303667	1812	stepic vegetation with rock cliffs
<i>D. uzzelli</i>	Ağrı	39.723639	43.002821	1638	stepic vegetation with rock cliffs
<i>D. bendimahiensis</i>	Muradiye	39.033783	43.757500	1760	stepic vegetation and river bank
<i>D. sapphirina</i>	35 km NW Erciş	39.188099	43.001953	1793	stepic vegetation and isolated rocks

Similar findings have been reported for the parthenogens among the 10 species of *Ameivula* (i.e. MENEZES *et al.* 2004), another teiid genus from South America, ecologically similar to *Aspidoscelis* (HARVEY *et al.* 2012).

Finally, from a demographic point of view, parthenogenetic lizards and particularly *Darevskia* tend to attain higher densities than their bisexual relatives (GALOYAN 2013). This, together with the low aggressiveness of parthenogenetic females allowing smaller home ranges (GALOYAN 2013), might enhance parasite transmission.

In accordance with the findings above mentioned, we here predict low or moderate gastrointestinal parasite infection in parthenogenetic *Darevskia* spp. Thus, here we analyze the helminth communities of three parthenogenetic forms inhabiting saxicolous restricted habitats from northeastern Anatolia.

MATERIAL AND METHODS

Due to the capture restrictions for these endangered species escaping extremely restricted ranges or even single localities, only 20 specimens of *D. uzzelli* were collected from two localities, five specimens of *D. bendimahiensis*, and two specimens of *D. sapphirina* from single localities, respectively, all of them in Northeast Anatolia and separated by no more than 100 km (Table 1). Climate of the region is characteristic of the Anatolian Plateau with strong continental influence contrasting between cold, snowy winters (-30°C) and dry, hot summers ($> 30^{\circ}\text{C}$) and with total annual precipitation averaging 400 mm (SENSOY *et al.* 2008).

Lizards were collected by hand, euthanized and dissected. While invasive, this method still ensures a better detection and quantification of intestinal parasites with a few specimens (JORGE *et al.* 2013). The gastrointestinal tracts were sent to the Laboratory of Parasitology of the University of Valencia for parasitological analysis. Helminths were processed in accordance with the usual techniques in parasitology (HORNERO 1991). We follow BUSH *et al.* (1997) in the use of descriptive ecological terms. Nematodes, voucher specimens are deposited in collection of Department of Zoology, Faculty of Biological Sciences, University of Valencia (Spain). Other data obtained from the searched hosts (taxonomy, thermoregulation, feeding habits, phylogeny, ecology), related with the geographical characteristics of the searched area are being object of other complex studies, according to DAMA protocol (Brooks *et al.* 2014).

Table 2. Comparative values of helminth infection and diversity among some Palaearctic lacertid lizards.

Host species	Helminth species found	Global prevalence	Mean intensity of infection	Mean abundance of infection	Brillouin's index of diversity
<i>Darevskia uzzelli</i> (n = 20)	1	10%	1±1 (1–1)	0.1±0.3 (0–1)	0
<i>Darevskia bendimahiensis</i> (n = 5)	1	20%	–	–	0
<i>Zootoca vivipara</i> (n = 129)	2	39.4%	2.4±2 (1–10)	0.9±1 (0–10)	0.002±0.02 (0–0.34)
<i>Podarcis bocagei</i> (n = 249)	5	13.7%	3.4±4.1 (1–27)	0.2±1.3 (0–27)	
<i>Podarcis carbonelli</i> (n = 257)	4	4%	4.2±5.3 (1–32)	0.1±1.2 (0–32)	0.001±0.02 (0–0.34)

RESULTS

Only one species of helminth, *Spauligodon saxicolae* (2 males and 2 females), was found in *D. uzzelli* and *D. bendimahiensis*. No parasites were found in *D. sapphirina*. The low number of helminths found and the poor conditions of conservation made impossible the specific identification of the parasites based in morphological characters. Prevalence of infection was 10% in *D. uzzelli*, 20% in *D. bendimahiensis*. Only one individual of *D. bendimahiensis* was infected. Mean intensity and mean abundance of infection in *D. uzzelli* were 1±1 (1–1) and 0.1±0.3 (0–1), respectively. Brillouin's diversity index was 0 in all the three hosts (Table 2).

DISCUSSION

Morphological species identification was compromised by the specimens conservation state. However, genetic analysis retrieved the specimens as closely related to *Spauligodon saxicolae* Sharpilo, 1961, as occurs with several similar morphotypes found in other *Darevskia* spp. from Armenia (JORGE *et al.* 2014).

Obviously, and considering the low number of examined hosts, we can only provide a preliminary description of the composition and structure of their helminth communities. Nevertheless these results are already extremely valuable because of the low probability to analyse more specimens of these endangered hosts in the next future.

The very low values of parasite infection and diversity cannot be attributed to sample size and suggest very poor helminth communities for these parthenogenetic host species. The *Darevskia* spp. analysed show the lowest diverse helminth communities reported to date within the Palaearctic lacertid lizards. Only *Podarcis bocagei* and *P. carbonelli* from North West of the Iberian Peninsula (GALDÓN *et al.* 2006), and *Zootoca vivipara* from Pyrenees (north of Iberian Peninsula) (SANCHIS *et al.* 2000) harboured equivalent impoverished helminth communities (Table 2). Is this the typical pattern in unisexual lizards? In this regard little is known on the parasites of other parthenogenetic lizards. Most data available come from *Aspidocelis* and *Ameivula* whiptail lizards (Teiidae). Studies of McALLISTER (1990a,b,c, 1992), McALLISTER *et al.* (1986, 1991a,b,c) and MENEZES *et al.* (2004) provide descriptions on the parasite infection of this group characterizing their helminth communities as follows.

Aspidocelis spp. harbour poor helminth communities, in many cases most lizards of a population contained only one helminth species (McALLISTER *et al.* 1991b). This agrees with our finding of a single species of the nematode *Spauligodon saxicolae*. Moreover, the infection and diversity values of the study parthenogenetic *Darevskia* spp. were poorer than those found in lizards which helminth communities have been considered as “extremely poor infracommunities” (GALDÓN *et al.* 2006) as the saurians mentioned above.

Usually parthenogenetic *Aspidocelis* spp. tend to be parasitized by the same helminths found in their parental species. For all the three *Darevskia* species studied, *D. valentini* is the paternal parent and *D. raddei* is the maternal parent (see Introduction). In *D. valentini*, four helminth species were found (ROCA *et al.*, unpubl. data) *Spauligodon saxicolae* being one of them. In *D. raddei*, only one species also belonging to *Spauligodon saxicolae* was recorded (ROCA *et al.* unpubl. data).

Parthenogenetic lizards usually share parasites with parthenogenetic and bisexual congeners, regardless of geographic location or even ancestry. *Spauligodon* spp. (sometimes named as *Skrjabinodon*, see JORGE *et al.* 2014) has been recorded in many saurian hosts in many geographical regions. Namely, they have been found in lacertids as *Podarcis* spp., *Algyroides marchi* or *Gallotia galloti* (ROCA & HORNERO 1994, LAFUENTE & ROCA 1995, ROCA *et al.* 2005), and geckos as *Tarentola mauritanica* (ROCA 1985a), in many areas of the Palaearctic and Macaronesia (see ROCA 1985b, HORNERO 1991, MARTIN 2005). Consequently, it seems that unisexual *Darevskia* spp. would share parasites with many other lacertid lizards.

Pharyngodonidae nematodes represent a substantial part of these depauperate helminth communities. This is also a typical pattern in Palaearctic lacertid lizards (see HORNERO 1991, MARTIN 2005, ROCA 1985b). In the present case the nematode *Spauligodon saxicolae* (Pharyngodonidae) encompasses the complete helminth communities present in all the three unisexual *Darevskia* hosts.

Thus, the pattern observed in parthenogenetic *Darevskia* spp. appears very similar to that in *Aspidocelis* spp. These very poor helminth communities could be explained by the decreasing of opportunities for interchanging helminths of direct life cycles, since there are neither male-female (reproductive) nor male-male contacts (territorial fights). Apparently, this effect takes precedence over the high lizard densities (GALOYAN 2013) in modelling the helminth communities of parthenogenetic *Darevskia* spp. Remarkably MENEZES *et al.* (2004) suggest that males of *Ameivula nativo* from Brazil would be more susceptible than females to infection by some nematodes. The fact that this host was also all-female, could also be associated with its relatively low infection rates.

The small body size of the host, and a low number of interactions with other reptile and amphibian species, have been cited as cause of very low diversity of helminths in the case of *Zootoca vivipara* (SANCHIS *et al.* 2000). Sandy areas, as zones where recruitment of parasites by lizard hosts is low (eggs being highly susceptible to desiccation), have been also cited as cause for low helminth community diversity for *P. bocagei* and *P. carbonelli* (GALDÓN *et al.* 2006). Nevertheless, infection rates were not significantly influenced either by host body size or by environmental factors in the case of the parthenogenetic whiptail lizard *Ameivula nativo* (MENEZES *et al.* 2004).

Although MORITZ *et al.* (1991) assume that differences in parasitism are attributable to differences in susceptibility between the sexual and the asexual lizards, CLAYTON *et al.* (1992) pointed out that parasite load alone does not accurately predict host susceptibility. HANLEY *et al.* (1995) argue that the Red Queen model predict shifts in host susceptibility to parasites within a population, but adds that other factors are important in determining patterns of parasitism such as transmission rates (ANDERSON & MAY 1982) or parasite virulence. The high densities attained by parthenogenetic lizards including *Darevskia* spp. (GALOYAN 2013 pers. obs.) should have increased infection opportunities but this was not the case here. Nevertheless, further studies with more populations and with other parthenogenetic forms of *Darevskia* are needed to untangle the factors modelling helminth parasitation.

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