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Helminth fauna of Spiny Tailed Lizard, *Darevskia rudis* (Bedriaga, 1886) (Sauria: Lacertidae) from Turkey

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Summary

The present study investigated the composition of helminth parasites of *Darevskia rudis,* Spiny Tailed Lizard from Turkey. One hundred and two samples (49♀♀, 53♂♂) from the Tokat, Trabzon, Rize, Gümüşhane and Artvin Provinces were collected and examined for helminth parasites. New host and locality records were recorded. As a result of the present study, seven species of Nematoda, *Skrjabinodon medinae*, *Spauligodon* sp., *Spauligodon carbonelli*, *Spauligodon aloisei*, *Skrjabinelazia hoffmanni*, *Strongyloides darevsky*, *Oswaldocruzia filiformis*; one species of Cestoda, *Mesocestoides* spp. (tetrathyridium) and one species of Acanthocephala *Sphaerirostris scanensis* were reported from the lizard samples. *Sp. carbonelli* and *Sphaerirostris scanensis* are here recorded for the first time in Turkey. *D. rudis* is the new host recorded for *Sk. medinae*, *Spauligodon* sp., *Sp. carbonelli*, *Sp. aloisei* from Nematoda, *Mesocestoides* spp. from Cestoda and *Sphaerirostris scanensis* from Acanthocephala. This host has been studied for the first time for the helminth parasites from the Tokat and Gümüşhane Provinces. There is, to our knowledge, only one report of helminthes for *D. rudis* in Turkey.

Keywords: *Darevskia rudis,* Helminth, Cestoda, Nematoda, Acanthocephala, Turkey

Introduction

Caucasian rock lizards (*Darevskia* spp.) are small lacertids from western Asia and south-eastern Europe. *Darevskia rudis*, Spiny Tailed Lizard, (Bedriaga, 1886) is a common species which occurs in Turkey (including northern Anatolia and the Middle Taurus Mountains), Georgia, Russia and Azerbaijan. This species ranges from sea level to 2400 m a.s.l., inhabiting rocky areas in temperate forests but it may also occurs in montane-steppe habitats and on the walls of buildings and other human structures (Baran *et al*., 2012; Arribas *et al*., 2013).

Both domestic and wild animals are hosts of a wide variety of parasitic species therefore some helminth parasites studies have been carried out in our country, especially for lacertid lizards. In Turkey, there are 39 species of lizards belonging to family Lacertidae. The species which have been studied for their helminth fauna are: *Lacerta viridis* (Schad *et al.,* 1960), *Podarcis tauricus* (Schad *et al.,* 1960), *Parvilacerta parva* (Saygı & Olgun, 1993), *Anatololacerta danfordi* (Gürelli *et al.,* 2007), *Lacerta trilineata* (Yıldırımhan *et al.,* 2011), *Eremias pleskei, E. strauchi*, *E. suphani* (Düsen *et al.* 2013), *Apathya cappadocica* (Birlik *et al.,* 2015), *Darevskia rudis* (Roca *et al.,* 2015a), *Darevskia uzzelli*, *D. bendimahiensis* and *D. sapphirina* (Roca *et al.,* 2015b), *D. clarkorum, D. raddei, D. parvula, D. valentini, D. armeniaca, D. unisexualis* (Roca *et al.,* 2016), *Phoenicolacerta laevis* (Birlik *et al.,* 2016), *Acanthocadtylus harranensis, A. schreiberi, Mesalina brevirostris* (Düşen *et al.,* 2016) and *Iranolacerta brandtii* (Birlik *et al.,* 2017).

To our knowledge, there is only one report of specific helminths

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in *Darevskia rudis*. The first study was conducted by Roca *et al.* (2015a). This is the second helminth study of this host in Turkey. Our objective is to gather information about the *D. rudis* helminth fauna and report on the differences between helminth species and present new locations of occurrence for the parasites.

Material and Methods

We examined 102 *D. rudis* specimens, of which 49 were adult females (SVL: 42.6 ± 2.3), and 53 adult males (mean snout-vent length: 57.85 ± 9.25 with a range from 31.61 to 82.98). Lizards were captured by hand from different localities of the Tokat, Trabzon, Rize, Gümüşhane and Artvin Provinces (Fig. 1). Lizard specimens were anesthetized with ether, fixed with a 96 % ethanol injection, and deposited in 96 % ethanol. The body cavity of the lizards was opened, and the digestive tract removed. The oesophagus, stomach, small and large intestine and lungs were opened and examined for helminths under a dissecting microscope. The Nematodes were killed in hot saline solution, fixed in 70 % ethanol, and mounted in glycerol. For the morphological examination, the helminth species were cleared gradually in glycerin. Cestodes were fixed in 70 % ethanol, stained with iron-carmine as described by Georgiev *et al*. (1986), cleared in clove oil, and mounted in Entellan. The parasites were identified, when possible, to species, and the number and location of the individuals of each species were recorded. Helminth identification was based on keys given by Yorke and Maplestone (1926), Schmidt (1986), Yamaguti (1961,1963), Baker (1987), Petter and Quentin (1976), Anderson (2000). Helminth voucher specimens were deposited in the Uludağ University, Department of Biology, Bursa, Turkey; lizard specimens were deposited in the Dokuz Eylül University, Department of Biology, İzmir, Turkey. Prevalence, mean intensity and mean abundance were determined according to Bush *et al.* (1997). Specifically, prevalence is the percentage infected of individuals, mean intensity is the estimated number of parasites per infected individual, measured in specimens per infected animal and finally mean abundance is the estimated number of parasites per total number of examined host, measured as specimens per analysed animal.

Results

Fifty-six lizards were infected (55 %) and nine species of helminths were identified (Table 1): seven species of Nematoda, *Skrjabinodon medinae*, *Spauligodon* sp., *Spauligodon carbonelli*, *Spauligodon aloisei*, *Skrjabinelazia hoffmanni*, *Strongyloides darevsky*, *Oswaldocruzia filiformis*; one species of Cestoda, *Mesocestoides* spp. (tetrathyridium) and one species of Acanthocephala *Sphaerirostris scanensis*. In total 175 individuals of nine parasite species were collected from 56 of the 102 Spiny-Tailed Lizards examined.

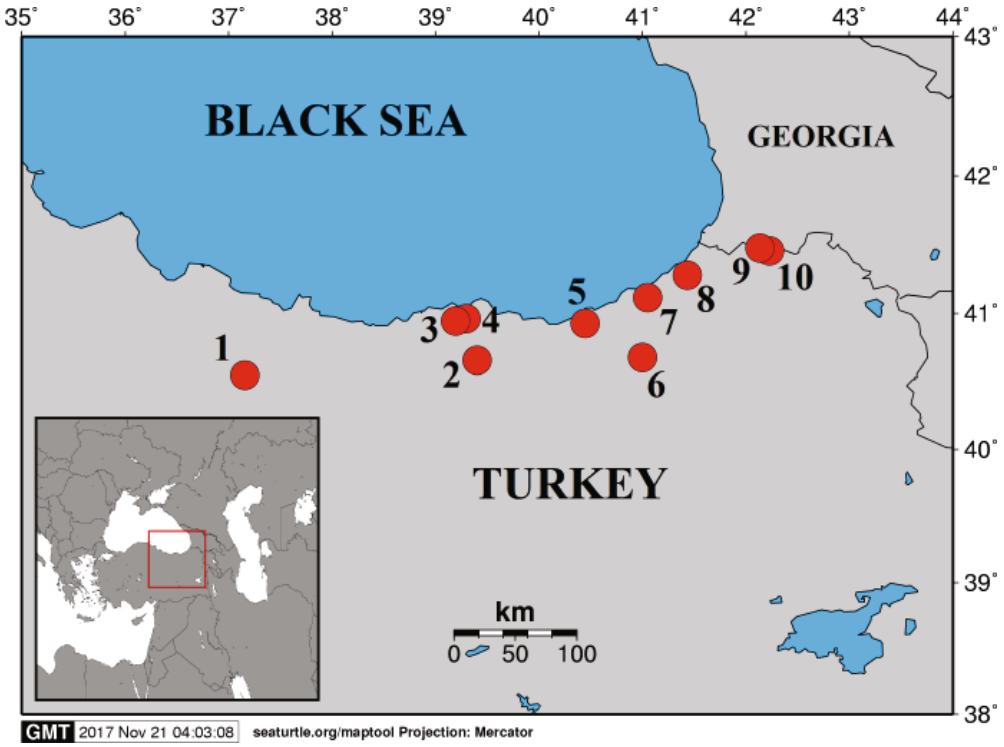

Fig. 1. The localities of host populations of *Darevskia rudis* (1. Karacaören, Başçiftlik, Tokat; 2. Zigana Pass, Gümüşhane; 3. Şalpazarı, Trabzon; 4. between Tonya and Vakfıkebir 10. km, Trabzon; 5. Kalkandere, Rize; 6. Ovit Pass, Rize; 7. Köprüköy, Rize; 8. Dülgerli Village, Ortacalar, Arhavi, Artvin; 9. Papart Plateau; 10. Meydancık Village, Şavşat, Artvin

There were nine helminth species represented in the lizards but no individual host harbored more than three helminth species. Of the infected lizards, 40 harbored one species of helminth, 15 harbored two species, one harbored three species. In this study, *D. rudis* is the new host record for *Sk. medinae*, *Spauligodon* sp., *Sp. carbonelli*, *Sp. aloisei* from Nematoda, *Mesocestoides* spp. from Cestoda and *Sphaerirorstris scanensis* from Acanthocephala. This host has been studied for the first time for helminth parasites from Tokat and Gümüşhane provinces. *Sp. carbonelli* and *Sphaerirostris scanensis* are recorded for the first time in Turkey. Prevalence, mean intensity and mean abundance of helminth species found in lizards were given in Table 1.

Table 1. Prevalence, mean intensity and mean abundance.

Helmint Species	Site of infection	Prevalence (%)	Mean intensity	Mean abundance
Nematoda				
Skrjabinodon medinae	Small intestine	33.33	2.2	0.73
Spauligodon sp.	Small intestine	4.9	2	0.09
Spauligodon carbonelli	Small intestine	9.8	2.2	0.21
Spauligodon aloisei	Small intestine	2.94	1.33	0.03
Strongyloides darevsky	Small intestine	10.78	4.18	0.45
Skrjabinelazia hoffmanni	Small intestine	0.98	1	0.009
Oswaldocruzia filiformis	Small intestine	1.96	2.5	0.04
Acanthocephala				
Sphaerirostris scanensis	Small intestine	1.96	1	0.019

Discussion

This study is the second helminth study on *D. rudis* specimens inhabited in Turkey. The First study was conducted by Roca *et al.* (2015a) on lizard specimens from the Ardahan, Artvin, Rize, Trabzon, Bursa, Düzce, Zonguldak, Karabük, Bolu and Bartın Provinces. In that study, one cestode *Nematotaenia tarentolae* and four nematode species, *Spauligodon saxicolae*, *Skrjabinelazia hoffmanni*, *Oswaldocruzia filiformis* and *Strongyloides darevskyi* were reported.

In the present study, specimens collected from Tokat, Trabzon, Rize, Gümüşhane and Artvin Proviences were studied. We found additional helminth species. These are *Sk. medinae*, *Sp. carbonelli*, *Sp. aloisei*, one species of Cestoda, *Mesocestoides* spp. (tetrathyridium) and one species of Acanthocephala, *Sphaerirostris scanensis*. Also, one species of Nematoda was identified as genus level *Spauligodon* sp.

In both studies, only three nematode species have been found in common. These species are *Strongyloides darevsky*, *Skrjabinelazia hoffmanni* and *Oswaldocruzia filiformis*. At present, *S. darevsky* is a *Darevskia* specialist. *Strongyloides* spp. have been recorded in different reptile hosts worldwide, including the species *S. cruzi* Rodrigues, 1968, *S. ophiusensis* Roca & Hornero, 1992 and *S. darevskyi* Sharpilo, 1976 described from lizards (Rodrigues, 1968, 1970; Sharpilo, 1973, 1976; Roca & Hornero, 1992; Khanum *et al*., 2002; Murvanidze *et al*., 2008). Moreover, unidentified *Strongyloides* spp. have also been reported in these reptiles (Perera *et al*., 2013). Although many species of *Strongyloides* show a low intensity of infection, higher prevalences of *S. darevskyi* (up to 75 %) with variable intensities of infection (1 – 55) were found in some populations of *Darevskia* spp. from Transcaucasia (Sharpilo, 1973, 1976). In addition to the type host *D. saxicola* (Eversmann, 1884), *S. darevskyi* was reported in *D. armeniaca* (Méhely, 1909), *D. rostombekovi* (Darevsky, 1957) and *D. rudis* (Bedriaga, 1886). This is the third record of this species in Turkey. The first one was reported in *D. rudis* by Roca *et al.* (2015a), the second is from *D. armeniaca* by Roca *et al*. (2016).

In Turkey, reports of *Strongyloides* spp. in lizards are scarce. This species was reported from two host in Turkey: *D. rudis* (Roca *et al.* 2015a) and *D. armeniaca* (Roca *et al*. 2016). *Strongyloides darevskyi* is in fact a true *Darevskia* specialist since it has been recorded only in species of this genus (Roca *et al*., 2016).

Skrjabinelazia Sypliaxov, 1930 (Seuratidae: Skrjabinelaziinae) (see Chabaud, 1978) is a rarely reported nematode genus (Baker, 1987) which is parasitic in the insectivorous saurians, the Gekkonidae and Lacertidae, and exceptionally in the Iguanidae (see Freitas, 1940), Scincidae (see Goldberg & Bursey, 1995) and Gerrhosauridae (see Caballero, 1968). Males of *Skrjabinelazia* are smaller than females and their lifespan is probably shorter; they are often scarce compared to females (Chabaud *et al*., 1988; Freitas, 1940). The nematode *S. hoffmanni* is a generalist species that has been recorded in some genera of Palaearctic lacertid lizards, such as *Podarcis*, *Darevskia* and *Lacerta*. This is the third record of *S. hoffmanni* in Turkey, other reports are from *Anatololacerta danfordi* (Gürelli *et al.,* 2007) and *D. rudis* (Roca *et al.,* 2015a).

Oswaldocruzia filiformis belongs to the Order Strongylida, Family Molineidae: Head with cuticular vesicles, cuticle with transverse striations and longitudinal ridges, mouth with indistinct lips and a short esophagus. In the present study, both female and male specimens were found. This is the fifth report of *O. filiformis* in Turkey. Other records: *Lacerta viridis* and *Podarcis tauricus*, (Schad *et al*., 1960); *Anguis fragilis* (Düşen *et al.,* 2010), *Lacerta trilineata,*

(Yıldırımhan *et al.,* 2011) and *Darevskia rudis* (Roca *et al.,* 2015a). In addition to these common species, we also found some helminth species of Nematoda – *Skrjabinodon mediane*, *Spauligodon aloisei*, *Sp. carbonelli* and *Spauligodon* sp.

Skrjabinodon medinae lacks caudal alae and possesses a single pair of sessile pre-cloacal papillae. This is the fourth report of this species from our country. Others: *Lacerta trilineata* (Yıldırımhan *et al.,* 2011), *Apatyha cappadocica* (Birlik *et al.,* 2015) and *Phoenicolacerta laevis* (Birlik *et al.,* 2016).

Species of *Spauligodon* are separated on the basis of the presence or absence of a spicule, the tail filament morphology, egg morphology, and geographical distribution. Currently, 52 species are assigned to *Spauligodon* (Bursey *et al.* 2014a; Pazoki & Rahimian 2014). Based upon the zoogeographic regions described by Holt *et al.* (2013), 16 species is known from the Palaearctic realm. *Spauligodon aloisei* is the only species from the Palaearctic region which has prebulbar vulva position among all *Spauligodon* species. Previously, this species was reported from *Iranolacerta brandthii* (Birlik *et al*. 2017). This study is the second record of the species in Turkey.

The nematode *S. carbonelli* has been only recorded in the lizards *Podarcis muralis*, *P. carbonelli* and *P. hispanica* from the Iberian Peninsula (García-Adell & Roca, 1988; Roca *et al.,* 1989; Galdon *et al.,* 2006), it may be considered a *Podarcis* specialist. Many *Spauligodon* spp. Found in Palaearctic region do not have a spicule. Only 5 of 22 species have spicule and *Sp. carbonelli* has a shorter (15 – 35 µm) spicule than other male specimens with a spicule (40 – 70 µm). Our male specimens have a short spicule (22 – 28 µm) and a spiny tail (1 – 5) and the females show postbulbar vulva. *Sp. carbonelli* is recorded for the first time in Turkey.

We found both *Spauligodon* and *Skrjabinodon* species. This correlates with 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).

Spauligodon saxicolae was found in a helminth study of *D. rudis* by Roca *et al.* (2015a) but we did not find this species in our lizard material. It is a nematode species of the Palaearctic region which have smooth tails in both male and female however males have no spicule. All of our nematode specimens found in this study have spiny tail and show spicules.

Mesocestoides spp., tetrathyridia are large, solid-bodied cysticercoids known only from the cyclophyllidean genus *Mesocestoides* are typically encountered embedded in the livers or coelomic mesenteries of their paratenic hosts. The genus has a worldwide distribution and is known from a great variety of amphibians and reptiles. It has been reported in the families Agamidae, Anguidae, Chamaeleonidae, Gekkonidae, Lacertidae and Scincidae (Witenberg, 1934; Hughes, 1940).The life cycle of species of *Mesocestoides* is believed to require 3 hosts: a vertebrate definitive host, a vertebrate second intermediate host, and an arthropod first intermediate host (Rausch, 1994). According to Specht and Voge (1965), the liver is the principal organ for natural infections in lizards. All the specimens found in this study were seen the liver. Tetrathyridia of the cyclophyllidean cestode, *Mesocestoides* sp. was reported previously from various lizards in Turkey *Anatalocerta danfordi* (Gürelli *et al.,* 2007), *Lacerta trilineata* (Yıldırımhan *et al.,* 2011), *Apatya cappadocica* (Birlik *et al.,* 2015), *Phoenicolacerta laevis* (Birlik *et al.,* 2016). This is the fifth report from lizards in Turkey.

Darevkia spp. show a lower prevalence of infection than the other continental Palaearctic rock lizards of the genus *Podarcis*. Roca *et al*. (2015a) associated these findings with the ecological characteristics of hosts and environment than in terms of the phylogeny of the lizard hosts.

***Sphaerirostris scanensis* (Lundström, 1942) Khokhlova, 1986,**

This species was recorded by Lundström (1942) from *Turdus merula* L., 1758 in Sweden. Comparing the morphometric data of the studied specimen with the original description, we found that the present species has a greater number of longitudinal rows of hooks – 28 versus 22 in the original description (Lundström, 1942) while the number of hooks per row and the morphology of the hook roots are comparable with those of *S. scanensis*. Another very similar species is *Sphaerirostris turdi* (Yamaguti, 1939) Golvan, 1956 described from thrushes and ortolans in Japan. The proboscis armament of this species consists of 26 – 34 longitudinal rows of hooks with 11 – 14 hooks per row (Yamaguti, 1939) and 26 rows x 11 – 13 hooks per row according to Kugi (1988). Velikanov (1989) recorded encysted juveniles (larvae) of this species from Lichtenstein's toadhead agama (*Phrynocephalus interscapularis* (Lichtenstein, 1856)) in Turkmenistan. However there aren't any reports of this species in Turkey.

56 of 102 (55 %) were infected by several helminth species but when the number of host specimens (102) was taken into consideration, the actual number of helminth (175) found were less. The biodiversity of helminth species was higher than in the study by Roca *et al.* (2015). These differences may be derived from season. Our lizard samples were collected in July and August. Samples studied by Roca *et al.* (2015a) were collected in spring. In particular, herbivorous reptiles are infected by different Pharyngodonidae than carnivores. Petter and Quentin (1976) recognized two evolutionary lineages (each one of them with different genera) parasitising carnivorous or herbivorous reptiles. Moreover, the structure of helminth communities is richer and more diverse in herbivorous reptiles (Roca and Hornero, 1992). It has been suggested (see Roca 1999) that the monoxenous life cycle typical of the Pharyngodonidae favours the infection of herbivorous reptile hosts because they have more opportunities to accidentally eat eggs deposited in plants through faecal pellets. Moreover, the increase of plant matter consumed provides a suitable environment for the development of a more rich and abundant helminth fauna (Petter and Quentin, 1976; Roca, 1999; Roca *et al.* 2005).

Several aspects of the biology and the ecology of lizards such as,

foraging modes, uses of microhabitats, body sizes, pregnancy, diet composition and ontogeny (Aho, 1990; Poulin, 1997) play a key roles in the acquisition of the associated helminth fauna. 13 *Darevskia* species inhabits in Turkey. Additional helminth studies are required to identify new helminth species, correlate the results with host characteristics and present new locality records. In summary, two new helminth records, six new host records and new geographic locality records are documented in this study.

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