



Helminh Parasites of Two Lacertid Species, *Anatololacerta anatolica* (Wermer, 1902) and *Darevskia rudis* (Bedriaga, 1886) (Sauria: Lacertidae) from Bursa Province, North-Western Turkey

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Abstract: Totally, 106 lacertid lizards of two species, *Anatololacerta anatolica* (n=63) and *Darevskia rudis* (n=43), from Bursa Province, Turkey, were examined for helminth parasites. In *Anatololacerta anatolica*, one species of Cestoda, *Mesocestoides* sp. (tetrathyridium), four species of Nematoda, *Skrjabinodon medinae*, *Spauligodon saxicolae*, *Skrjabinelazia hoffmanni* and *Ascarops strongylina* (larva in cysts), and one species of Acanthocephala, *Plagiorhynchus* sp. (cystacanth), were found. In *Darevskia rudis*, two nematode species, *Skrjabinodon medinae* and *Spauligodon saxicolae*, were recorded. The helminth species reported in this study are generalists infecting more than one host species.

Key words: Squamata, Lacertidae, Parasites, Cestoda, Nematoda, Acanthocephala.

Introduction

Anatolian rock lizard *Anatololacerta anatolica* (Werner, 1902) inhabits rocky areas and loose stone walls in forested or wooded areas not far from water. This species inhabits western parts of Anatolia (BELLATI et al. 2015), with a vertical distribution up to 1200 m. The spiny tailed lizard *Darevskia rudis* (Bedriaga, 1886) is a common species that occurs in Turkey (including northern Anatolia and the Middle Taurus Mountains), Georgia, Russia and Azerbaijan. This species ranges from the sea level to 2400 m, inhabiting rocky areas in temperate forests but may also occur in montane-steppe habitats and on the

walls of buildings and other human-made structures (BARAN & ATATÜR 1998).

To our knowledge, the present study is the first helminthological survey on *A. anatolica*. There are two reports of helminth parasites from *D. rudis* from Turkey. ROCA et al. (2015a) reported five species of helminth parasites: *Spauligodon saxicolae*, *Skrjabinelazia hoffmanni*, *Oswaldocruzia filiformis*, *Strongyloides darevskyi* and *Nematotaenia tarentolae*. BİRLİK et al. (2018a) recorded nine helminth species from this host: *Mesocestoides* spp. (tetrathyridia), *Skrjabinodon medinae*, *Spauligodon* sp., *Spauligodon carbonelli*, *Spauligodon aloisei*, *Skrjabinelazia hoffmanni*, *Strongyloides darevskyi*, *Oswaldocruzia*

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filiformis and *Sphaerirostris scanensis*. However, no data have been published on the helminth parasites from *D. rudis* from Bursa Province, NW Turkey.

This study provides new helminthological data for *A. anatolica* and *D. rudis* from Bursa Province, Turkey.

Materials and Methods

Lizards were humanely sacrificed with sodium pentobarbital. The body cavity was opened and the digestive tract was removed. The oesophagus, stomach, small and large intestines and lungs were opened and separately examined for helminths under a dissecting microscope. Cestodes and Acanthocephala were fixed in 70% ethanol, stained with iron carmine, dehydrated, cleared, and mounted in Entellan (Merck). Nematodes were killed in hot saline solution, fixed in 70% ethanol, cleared in a drop of glycerol, mounted on glass slides and identified from temporary mounts. Helminth identifications were based on the reference keys of SCHMIDT (1986) and YAMAGUTI (1961). Helminth voucher specimens were deposited in the Helminthological Collection of Uludağ University Museum of Zoology, Bursa, Turkey. Lizard specimens were deposited in the Department of Biology, Uludağ University, Bursa, Turkey.

Results

Anatolian rock lizard *Anatololacerta anatolica* (Werner, 1902)

Sixty-three specimens of the Anatolian rock lizard *Anatololacerta anatolica* (26 males, 33 females and 4 juveniles) were collected by hand in 1996-1998 from seven locations of Bursa Province. Numbers of lizards were as follows: n=16 at Sogukpınar, n=11 at Misi Village, n=11 at Keles Route, n=9 at Uludağ Route and n=16 at İnegöl.

The following helminth species were recorded:

Mesocestoides sp. (tetrathyridia)

Prevalence, mean intensity and range: 3 of 63 (5%), 26 ± 6, 20-32.

Temporal distribution: 10 May 1997, 1 host with 32; 6 September 1998, 2 hosts with 26 and 20.

Site of infection: Body cavity.

Other records from Turkey: *Anatololacerta danfordi* (see GÜRELLI et al. 2007), *Lacerta trilineata* (see YILDIRIMHAN et al. 2011), *Apathya cappadocica* (BIRLIK et al. 2015), *Phoenicolacerta laevis* (BIRLIK et al. 2016), *Darevskia rudis* (BIRLIK et al. 2018a) and *Darevskia valentini* (BIRLIK et al. 2018b).

Other reported reptilian hosts: The genus *Mesocestoides* is cosmopolitan and tetrathyridia can be found in various classes of vertebrates. We have listed known accidental or paratenic hosts reported from the Palaearctic: redbelly rock agama *Para-*

laudakia erythrogaster (reported as *Agama erythrogaster*, see RADCHENKO 1973); Spanish psammodromus *Psammodromus hispanicus* (ROCA et al. 1986a, ROCA & LLUCH 1988); Tenerife wall gecko *Tarentola delalandii* (ROCA et al. 1987); Iberian emerald lizard *Lacerta schreiberi* (ROCA & FERRAGUT 1989); Bocage's wall lizard *Podarcis bocagei* (ROCA et al. 1989); Iberian wall lizard *Podarcis hispanica* (ROCA et al. 1989); slow worm *Anguis fragilis* (LEWIN 1990); Ibiza wall lizard *Podarcis pityusensis* (ROCA & HORNERO 1991, ROCA & HORNERO 1994); sand lizard *Lacerta agilis* (LEWIN 1992a, SHARPILO et al. 2001, NELLI et al. 2014); *Lacerta viridis* (BISERKOV & KOSTADINOVA 1998); common wall lizard *Podarcis muralis* (KIRIN 2002); Secret toadhead agama *Phrynocephalus mystaceus* (IKROMOV & CHO 2004); eastern giant emerald lizard *Lacerta media* (NELLI et al. 2014); Snake-eyed lizard *Ophisops elegans* (NELLI et al. 2014); Mongolian racerunner *Eremias argus* (DUGAROV et al. 2018). Halys pit viper *Gloydius halys* (reported as *Ancystrodon halys*, see BOGDANOV et al. 1969); European grass snake *Natrix natrix* (LEWIN 1992b); nose-horned viper *Vipera ammodytes* (BISERKOV 1995); smooth snake *Coronella austriaca* (BISERKOV 1996); Aesculapean snake *Zamenis longissimus* (reported as *Elaphe longissima*, see BISERKOV 1996); Western whip snake *Hierophis viridiflavus* (SANTORO et al. 2013).

Geographic range: Cosmopolitan (MCALLISTER et al. 1991).

Remarks: The life cycle of *Mesocestoides* spp. is thought to require 3 hosts, i.e. a vertebrate definite host, a vertebrate second intermediate host, and a purported arthropod first intermediate host (RAUSCH 1994). Tetrathyridia are frequently found in the body cavities of amphibians, reptiles, birds and mammals (PADGETT & BOYCE 2004). *Anatololacerta anatolica* represents the eighth host species record for the genus *Mesocestoides* in Turkey.

Skrjabinelazia hoffmanni Li, 1934

Prevalence, mean intensity and range: 11 of 43 (26%), 12 ± 20.23, 1-70.

Temporal distribution: 5 May 1998, 1 host with 3; 9 June 1998, 5 hosts with 7, 5, 3, 70 and 1; 1 July 1998, 3 hosts with 2, 20 and 4; 7 July 1998, 2 hosts with 17 and 1.

Site of infection: Small intestine.

Type host and type locality: Mongolian racerunner *Eremias argus*, China (LI 1934).

Other records from Turkey: *Lacerta trilineata* (YILDIRIMHAN et al. 2011); *Darevskia rudis* (ROCA et al. 2015a, BIRLIK et al. 2018a); *Darevskia valentini* (BIRLIK et al. 2018b).

Other reports: Comb-toed gecko *Crossobamon evermanni* (ANDRUSKO & MARKOV 1956, SHARPILO 1976); *Darevskia saxicola* (reported as *Lacerta saxicola*, see SHARPILO 1976); *Teratoscincus scincus* (SHARPILO 1976); Azerbaijan lizard *Darevskia raddei* (reported as *Lacerta raddei*, see KHOMUSTENKO & ATAIEV 1979); *Eremias argus* (LI 1934; DUGAROV et al. 2018); Kirghiz racerunner, *Eremias nikolskii* (SHARPILO 1976); *Lacerta agilis* (SHARPILO 1976, SHARPILO et al. 2001); *Lacerta viridis* (BISERKOV & KOSTADINOVA 1998); *Podarcis bocagei* (ROCA et al. 1990; GALDON et al. 2006); *Podarcis hispanica* (ROCA et al. 1990); Lilford's wall lizard *Podarcis lilfordi* (HORNERO & ROCA 1992a, ROCA & HORNERO 1994); *Podarcis muralis* (ROCA et al. 1990, KIRIN 2002); Carbonell's wall lizard *Podarcis carbonelli* (GALDON et al. 2006); Canary wall gecko *Tarentola angustimentalis* (ROCA et al. 1999).

Geographic range: China (LI 1934); Central Asia (ANDRUSKO & MARKOV 1956); Azerbaijan (KHOMUSTENKO & ATAIEV 1979); Spain (ROCA et al. 1990); Bulgaria (BISERKOV & KOSTADINOVA 1998); Ukraine (SHARPILO et al. 2001); Portugal (GALDON et al. 2006); Turkey (YILDIRIMHAN et al. 2011); Rus-

sia (DUGAROV et al. 2018).

Remarks: The life history of *S. hoffmanni* apparently has not been studied. However, the congener *S. galliardi* is claimed to produce two types of eggs, one thin-shelled and containing third-stage larva, probably autoinfective, and a second, red, thicker shelled, with third-stage larvae, which probably pass out of the host (CHABAUD et al. 1988). *A. anatolica* represents the fourth reptilian host species recorded for *Skrjabinelazia hoffmanni* in Turkey.

***Skrjabinodon medinae* (García-Calvente, 1948) Specian & Ubelaker, 1974**

Syn. *Pharyngodon medinae* García-Calvente, 1948; *Parathelandros medinae* (García-Calvente, 1948) Read & Amrein 1953

Prevalence, mean intensity and range: 20 of 63 (32%), 4.9 ± 3.11, 2-12.

Temporal distribution: 25 May 1996, 5 hosts with 4, 1, 10, 4, 2 and 12; 30 April 1997, 2 hosts with 10 and 4; 10 May 1997, 2 hosts with 2 and 5; 5 May 1998, 2 hosts with 18 and 2; 9 June 1998, 1 host with 6; 1 July 1998, 1 host with 6; 7 July 1998, 1 host with 2; 19 July 1998, 3 hosts with 1, 5 and 12; 6 September 1998, 3 hosts with 5, 3 and 5.

Site of infection: Large intestine.

Type host and type locality: *Lacerta muralis*, Spain (GARCIA-CALVENTE 1948).

Other records from Turkey: *Lacerta trilineata* (YILDIRIMHAN et al. 2011), *Apathya cappadocica* (BIRLIK et al. 2015), *Phoenicolacerta laevis* (BIRLIK et al. 2016), *Iranolacerta brandtii* (BIRLIK et al. 2017), *Darevskia rudis* (BIRLIK et al. 2018a), *Darevskia valentini* (BIRLIK et al. 2018b).

Other reports: *Lacerta schreiberi* (ROCA & FERRAGUT 1989); *Podarcis bocagei* (ROCA et al. 1989); *Podarcis hispanica* (ROCA et al. 1986b, 1989, ROCA & LLUCH 1988, HORNERO & ROCA 1992a); Lilford's wall lizard *Podarcis lilfordi* (HORNERO & ROCA 1992b, ROCA & HORNERO 1994); *Podarcis muralis* (DOLLFUS et al. 1961, GARCIA-CALVENTE 1948, HORNERO & ROCA 1992a); *Podarcis pityusensis* (ROCA & HORNERO 1991, 1994, HORNERO & ROCA 1992a); *Zootoca vivipara* (reported as *Lacerta vivipara*, DOLLFUS et al. 1961).

Geographic range: France (DOLLFUS et al. 1961); Spain (ROCA & HORNERO 1994); Turkey (YILDIRIMHAN et al. 2011).

Remarks: *Anatololacerta anatolica* represents the seventh host record for the species *Skrjabinodon medinae* in Turkey.

***Spauligodon saxicola* Sharpilo, 1961**

Prevalence, mean intensity and range: 17 of 63 (27%), 11.6 ± 9.2, 2-30.

Temporal distribution: 21 September 1996, 2 hosts with 25 and 8; 30 April 1997, 2 hosts with 30 and 6; 9 June 1998, 2 hosts with 6 and 12; 24 June 1998, 1 host with 16; 6 September 1998, 2 hosts with 2 and 3; 26 October 1998, 8 hosts with 12, 6, 6, 16, 14, 30, 4 and 2.

Site of infection: Large intestine.

Type host and type locality: Scaly lizard *Lacerta saxicola*, Ukraine (SHARPILO 1961).

Other records from Turkey: *Darevskia rudis* (MURVANIDZE et al. 2008; ROCA et al. 2016); *Eremias strauchi* (DÜŞEN et al. 2013); *E. suphani* (DÜŞEN et al. 2013); *Darevskia bendimahiensis* (ROCA et al. 2015a); *D. sapphirina* (ROCA et al. 2015b); *D. uzzelli* (ROCA et al. 2015b); *D. clarkoru* (ROCA et al. 2016); *D. parvula* (ROCA et al. 2016); *D. raddei* (ROCA et al. 2016); *D. unisexualis* (ROCA et al. 2016); *D. valentini* (ROCA et al. 2016); *Mesalina brevirostris* (DÜŞEN et al. 2016).

Other reports: *Darevskia saxicola* (GOLDIN 1975,

MURVANIDZE et al. 2008); *Eremias velox* (IKROMOV & CHO 2004); *Darevskia caucasica* (UHLIROVA 2005); *Lacerta strigata* (MURVANIDZE et al. 2008); *Darevskia rudis* (MURVANIDZE et al. 2008); *Coluber jugularis* (MURVANIDZE et al. 2008); *Podarcis vaucheri* (CARRETERO et al. 2011).

Geographic range: Crimea (GOLDIN 1975); Azerbaijan (UHLIFOVA 2005); Georgia (MURVANIDZE et al. 2008); Algeria (CARRETERO et al. 2011); Turkey (DÜŞEN et al. 2013).

Remarks: *A. anatolica* represents the 12th reptilian host record for *Spauligodon saxicola* in Turkey.

***Ascarops strongylina* (Rudolphi, 1819) Alicata & McIntosh, 1933 (larvae in cysts)**

Syn. *Spiroptera strongylina* Rudolphi, 1819

Prevalence and intensity: 1 of 63, (2%), 2.

Temporal distribution: 6 September 1998, 1 host with 2.

Site of infection: cysts on stomach wall.

Type host and type locality: Mammal, pig, *Sus scrofa*, Europe (RUDOLPHI, 1819).

Other records from Turkey: *Lacerta trilineata* (YILDIRIMHAN et al. 2011).

Other reports: Amphibia: *Bufo viridis* (VASHETKO & SIDDIKOV 1999); Reptilia: *Anguis fragilis* (SHIMALOV et al. 2000); *Lacerta agilis* (SHIMALOV et al. 2000, SHARPILO et al. 2001); *Zootoca vivipara* (reported as *Lacerta vivipara*) (SHIMALOV et al. 2000); *Gloydius halys* (reported as *Ancystrodon halys*) (BOGDANOV et al. 1969); large whip snake *Dolichophis jugularis* (reported as *Coluber jugularis*) (BISERKOV 1995); Dahl's whip snake *Platyceps najadum* (reported as *Coluber najadum*) (BISERKOV 1995); *Malpolon monspessulanus* (BISERKOV 1995); *Coronella austriaca* (SHIMALOV & SHIMALOV 2000); *Natrix natrix* (SHIMALOV & SHIMALOV 2000); *Vipera berus* (SHIMALOV & SHIMALOV 2000); Asp viper *Vipera aspis* (SANTOS et al. 2006); Latate's viper *Vipera latastei* (SANTOS et al. 2006).

Geographic range: Cosmopolitan (YAMAGUTI 1961). Only western Palaearctic records of larval infections are given here: Russia (BOGDANOV et al. 1969); Bulgaria (BISERKOV 1995); Uzbekistan (VASHETKO & SIDDIKOV 1999); Belarus (SHIMALOV et al. 2000); Ukraine (SHARPILO et al. 2001); Spain (SANTOS et al. 2006); Turkey (YILDIRIMHAN et al. 2011).

Remarks: Larvae in cysts are frequently found in the body cavities of amphibians, reptiles, birds and mammals (GOLDBERG & BURSEY 2000). *Anatololacerta anatolica* represents a new host record for larva of *Ascarops strongylina*. *A. anatolica* represents the second reptilian host record for *Ascarops strongylina* in Turkey.

***Plagiorhynchus* sp. (cystacanth)**

Prevalence and range: 1 of 63 (2%), 1.

Temporal distribution: 10 May 1997, 1 host with 1.

Site of infection: Large intestine.

Type host and type locality: Sanderling *Calidris arenaria*, Brittany, France (VILLOT 1875). Species of *Plagiorhynchus* are mainly parasitic in charadriiform birds.

Other records from Turkey: None.

Other reports: None in reptiles.

Geographic range: Western Europe (SKRJABIN & KOVAL 1958).

Remarks: Eggs of acanthocephalans are released when they are fully mature and infective (CHITFIELD 1970). Two hosts are generally required; arthropods are the usual intermediate hosts in which the infective stage, the cystacanth develops; vertebrates are the definitive host (NEAR 2002). Any insectivore might be expected to harbour cystacanths. *Anatololacerta anatolica* represents the first reptilian host record for cystacanths of *Plagiorhynchus* sp. in Turkey.

Spiny-tailed lizard *Darevskia rudis* (Bedriaga, 1886)

Forty-three specimens of the spiny-tailed lizard *Darevskia rudis* (Bedriaga, 1886) (25 males, 17 females, 1 juvenile) were collected by hand in 1995-1998 from two locations of Bursa Province. Numbers of examined lizards were n=32 at Cobankaya and n=11 at Kirazlıyayla.

***Skryabinodon medinae* (García-Calvente, 1948) Specian & Ubelaker, 1974**

Syn. *Pharyngodon medinae* García-Calvente 1948; *Parathelandros medinae* (García-Calvente, 1948) Read & Amrein 1953

Prevalence, mean intensity and range: 10 of 43 (23%), 4.3 ± 2.11, 1-7.

Temporal distribution: 13 May 1997, 1 host with 7; 15 June 1998, 3 hosts with 3, 8 and 5; 23 July 1998, 1 host with 5; 20 August 1998, 5 hosts with 5, 1, 3, 3 and 3.

Site of infection: Large intestine.

Remarks: See remarks above under *Anatololacerta anatolica*.

***Spauligodon saxicolae* Sharpilo, 1961**

Prevalence, mean intensity and range: 29 of 43 (44%), 9.7 ± 10.87, 1-45.

Temporal distribution: 5 July 1995, 1 host with 2; 13 May 1997, 1 host with 28; 22 May 1999, 5 hosts with 2, 6, 5, 2 and 2; 7 June 1998, 2 hosts with 9 and 1; 15 June 1998, 6 hosts with 4, 1, 30, 20, 1 and 1; 23 July 1998, 2 hosts with 1 and 1; 20 August 1998, 12 hosts with 5, 1, 1, 10, 2, 6, 3, 1, 4, 8, 25 and 9.

Site of infection: Large intestine.

Remarks: See remarks above under *Anatololacerta anatolica*.

Discussion

Forty-two (67%) of 63 *Anatololacerta anatolica* harboured 509 helminths representing 6 species: 30 lizards harboured 1 species, 10 harboured 2 species and 1 harboured 3 species. There were 12.1 ± 13.4 SD (range 1-70) helminth individuals per host lizard and 1.2 ± 0.5 SD helminth species per host lizard.

Twenty-nine (67%) of 43 *Darevskia rudis* harboured 324 helminths representing 2 species: 19 lizards harboured 1 species and 10 harbored 2 species. There were 9.7 ± 12.9 SD (range 1-50) helminth individuals per host and 1.3 ± 0.5 SD helminth species per host.

Of the 147 Turkish reptile species (UETZ 2019), helminth lists are available for 25 species: *Anatololacerta danfordi* (Gunther, 1876), *Acanthodactylus schreiberi* Boulenger, 1878, *Acanthodactylus har-ranensis* Baran, Kumlutas, Llanza, Sindaco, Avci and Crucitti, 2005, *Apathya cappadocica* (Werner, 1902), *Darevskia rudis* (Bedriaga, 1886), *Darevskia raddei* (Boettger, 1892), *Darevskia valentini* (Boettger, 1892), *Darevskia armeniaca* (Mehely, 1909), *Darevskia parvula* (Lantz and Cyren, 1913), *Darevskia unisexualis* (Darevsky, 1966), *Darevskia clarkorum* (Darevsky and Vedmederja, 1977), *Darevskia*

uzzellis (Darevsky and Danielyan, 1977), *Darevskia bendimahiensis* (Schmidtler, Eiselt and Darevsky, 1994), *Darevskia sapphirina* (Schmidtler, Eiselt and Darevsky, 1994), *Eremias strauchi* Kessler, 1878, *Eremias pleskei* Nikolsky, 1905, *Eremias suphani* Basoglu and Hellmich, 1986, *Iranolacerta brandtii* (De Filippi, 1863), *Lacerta viridis* (Laurenti, 1768), *Lacerta trilineata* Bedriaga, 1886, *Podarcis tauricus* (Pallas, 1814), *Mesalina brevis* Blanford, 1874, *Phoenicolacerta laevis* (Gray, 1883) and *Parvilacerta parva* (Boulenger, 1887).

This report revises the helminth list for *Anatololacerta anatolica*, increasing its known helminths from one to six; however, additional studies will be required before the component community of helminths infecting Turkish lizards can be determined. For the 24 species listed above, there are on average 3.4 ± 3.3 SD (range 1-11) helminth species per lizard species. Currently, we can say that Turkish lizards are infected by generalist nematodes, i.e. nematode species that infect more than one host species.

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