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The helminth fauna of *Apathya cappadocica* (Werner, 1902) (Anatolian Lizard) (Squamata: Lacertidae) from Turkey

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Summary

A total of thirty-one Anatolian Lizard, *Apathya cappacocica*, samples from several provinces of Eastern and South-Eastern Turkey were examined for helminths. Two species of Nematoda, including *Spauligodon atlanticus, Skrjabinodon medinae*; two species of Cestoda, including *Mesocestoides* sp. tetrahydia and *Oochoristica tuberculata* and one species of Acanthocephala, *Centrorhynchus* sp. were found. This is the first helminth record of *A. cappodocica* from Turkey. *A. cappadocica* represents a new host record for each of the parasite species. *S. atlanticus* is reported from Turkey for the first time.
Keywords: Nematoda; Cestoda; Acanthocephala; Anatolian lizard; *Apathya cappadocica*; Turkey

Introduction

The Anatolian Lizard, *Apathya cappadocica* (Werner 1902) is found in Turkey (central, eastern, southern and southeastern Anatolia), northern Syria, northern Iraq, and northwestern Iran (Ilgaz *et al*., 2010; Baran *et al*., 2012). *A. cappadocica* is medium sized lizard with a total length up to 25 cm. The vertical distribution of the species varies from 300 and 1.700 m. asl. This species was found exclusively in rocky, stony or pebbly areas and outcrops with sparse vegetation and rock mounds. It is occasionally seen in wooded areas. It could move easily from sunlight to shadow and could take refuge in crevices. The females lay between three and seven eggs. It is not known from modified habitats (Baran & Atatür, 1998; Clark & Clark, 1973; Anderson, 1999).

To our knowledge, only 14 (20 %) of the 69 lizards reported to occur in Turkey (Uetz, 2012) have been examined for helminths: Danford's Lizard, *Anatololacerta danfordi* (Gürelli *et al*., 2007); Slow Worm, *Anguis fragilis* (Schad *et al*., 1960) Turkish Worm Lizard, *Blanus strauchi* (Yıldırımhan *et al*., 2009); Turkish Gecko, *Hemidactylus turcicus* (Tinar, 1982), Balkan Emerald Lizard, *Lacerta trilineata* (Yıldırımhan *et al*., 2011); European Green Lizard, *Lacerta viridis* (Schad *et al*., 1960); Caucasian Agama, *Paralaudakia caucasia* (Yıldırımhan *et al*.,2006); Roughtail Rock Agama, *Stellagama stellio* (Yıldırımhan *et al*., 2006); Dwarf Lizard, *Parvilacerta parva* (Saygı & Olgun, 1993); Crimean Wall Lizard, *Podarcis tauricus* (Schad *et al*., 1960); Pleske's Racerunner-Transcaucasian Racerunner**,** *Eremias pleskei,* Strauch's Racerunner*, Eremias strauchi,* Suphan Racerunner, *Eremias suphani* (Düsen *et al*., 2013); Ocellated Skink *Chalcides ocellatus* (Incedogan *et al*., 2014).

This is the first detailed helminthological study conducted on *A. cappadocica* from Turkey. The purpose of this paper is to provide an initial helminth list for *A. cappadocica.*

Material and Methods

In total a thirty-one lizard samples were collected in 2014 from 5 localities in Turkey. The locations of all of the study sites within 5 localities in Turkey are shown in Fig.1. Thirty-one specimens of *A. cappadocica* (12 males, 15 females, 4 subadult, mean snout-vent length = 68,57 ± 11,46 mm, with a range from 46.0 to 87.0 mm) were collected by hand in 2014 from Karabıyıklı village, Pazarcık, Kahramanmaraş (4) (37°18'N, 37°11'E, 930 m elevation, on 29 April 2014, n=12), Sakçagözü, Nurdağı, Gaziantep (3) (37°10'N, 36°56'E, 806 m elevation, on 29 April 2014, n= 4), Ceylanlı, Kırıkhan, Hatay (1) (36°33'N, 36°22'E, 278 m elevation, on 1 May 2014, n=2), between Kilis and Hassa 32. km, Kilis (2) (36°50'N, 36°53'E, 540 m elevation, on 2 May 2014, n=6) and

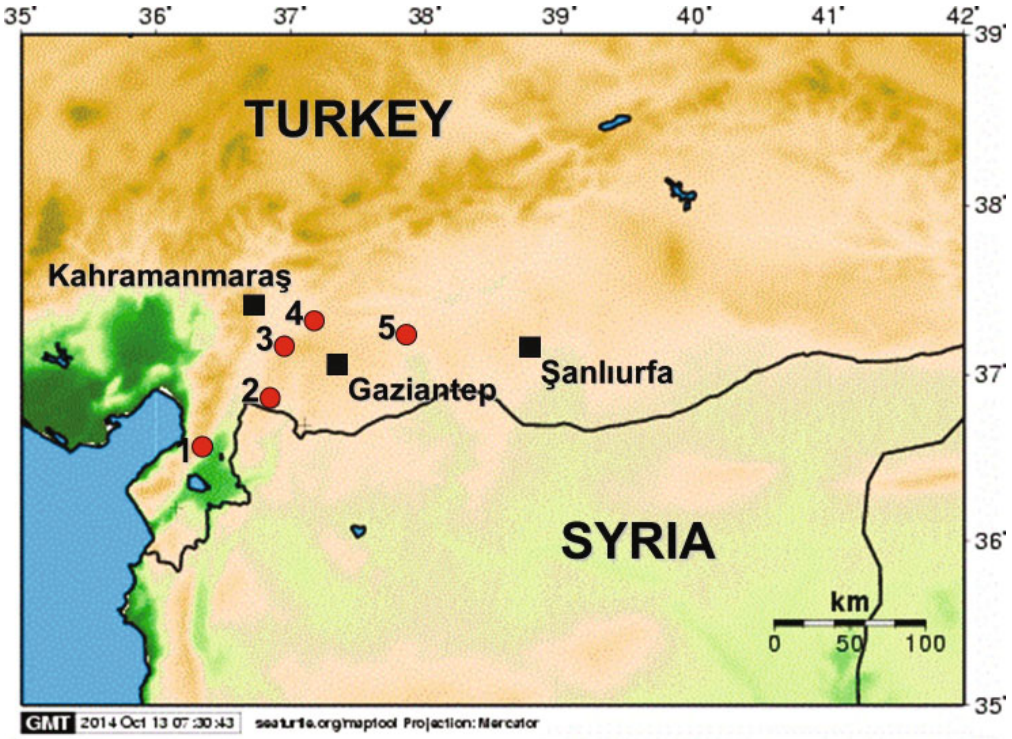

Fig.1. The collection locations of *Apathya cappadocica* from eastern and South-eastern part of Turkey

Halfeti, Şanlıurfa (5) (37°14'N, 37°53'E, 590 m elevation, on 2 May 2014 n=7) Turkey. Lizards were transported to the laboratory, over-anaesthetized with ether, sexed and body lengths measured. The body cavity was opened by a longitudinal incision and the gastro-intestinal tract was removed by cutting across the oesophagus and rectum. The esophagus, stomach, small and large intestine, and lungs were opened and separately examined for helminths under a dissecting microscope. Nematodes were killed in hot saline solution, fixed in 70 % ethanol, and mounted in glycerol. 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®. Helminth identification was based on keys given by Schmidt (1986), Petter and Quentin (1976), Yorke and Maplestone (1926), Yamaguti (1961, 1963), Baker (1987), Bray *et al*. (2008). Parasites were identified, when possible, to species, and the number and location of individuals of each species were recorded. The use of descriptive ecological terms follows Bush *et al*. (1997).
Helminth voucher specimens were deposited in the helminth collection of Uludag University Museum of Zoology, Bursa, Turkey. Lizard specimens were deposited in the Department of Biology, Dokuz Eylül University, İzmir, Turkey.

Results

Five species of helminth parasites were detected in Anatolian Lizard. These species were *Mesocestoides* sp., *Oochoristica tuberculata* (Cestoda); *Spauligodon atlanticus*, *Skrjabinodon medinae* (Nematoda); and *Centrorhynchus* sp. (Acanthocephala). Of 31 *A. cappadocica* 21 (67 %) were infected with one or more parasites. Of 31 host lizard 10 (32 %) were infected by any parasite species. Total 235 individuals of 5 parasite species were collected from 21 Anatolian lizards.

Table1. Prevalence, mean intensity and mean abundance

Helminth species	Site of infection	Prevalence (%)	Mean intensity	Mean abundance
Cestoda				
Mesocestoides sp. (larvae)	body cavity	9.67	14	1.35
Oochoristica tuberculata	small intestine	3.22	1	0.03
Nematoda				
Skrjabinodon medinae	caecum	45.16	6.21	2.80
Spauligodon atlanticus	large intestine	41.93	7.69	3.22
Acanthocephala				
Centrorhynchus sp.	body cavity	9.67	1.66	0.16

Table 2. The lizard species studied in Turkey and identified helminth species.
(1. Schad et al. (1960) 2. Yıldırımhan et al. 2009 3. Tınar 1982. 4. Tınar 1983 5. Yıldırımhan et al. 2008 6. Saygı and Olgun 1993, 7. Yıldırımhan et al. 2011 8. Yıldırımhan et al. 2006 9.Gürelli et al. 2007 10. Düşen et al. 2013 11. Incedogan et al. 2014 12. *Current study)

	Anguis fragilis	*Blanus strauchi*	*Hemidactylus turcicus*	*Lacerta trilineata*	*Lacerta viridis*	*Podarcis tauricus*	*Parvilacerta parva*	*Stellegama stellio*	*Paralaudakia caucasica*	*Anatolalacerta danfordi*	*Chalcides ocellatus*	*Eremias pleskei*	*Eremias strauchi*	*Eremias suphani*	**Apathya cappadocica*
Digenea															
Plagiorchis elegans	---	---	---	7	---	---	---	---	---	---	---	---	---	---	---
Pleurogenoides medians	---	---	---	7	---	---	---	---	---	---	---	---	---	---	---
Brachylaima sp. (metacercaria)	---	---	---	7	---	---	---	---	---	---	11	---	---	---	---
Cestoda															
Oochoristica tuberculata	---	---	---	7	---	---	---	---	8	---	11	---	---	10	12
Joyeuxiella pasqualei	---	---	4	---	---	---	---	---	---	---	---	---	---	---	---
Mesocestoides sp. (tetrathyridia)	---	---	---	7	---	---	---	---	---	9	---	---	---	---	12
Nematoda															
Abbreviata abbreviata	---	---	---	7	---	---	---	---	---	---	---	---	---	---	---
Ascarops strongylina (larva)	---	---	---	7	---	---	---	---	---	---	---	---	---	---	---
Ascaridae (larva)	---	---	---	---	---	---	---	8	---	---	---	---	---	---	---
Entomelas entomelas	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Entomelas dujardini	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Falcaustra armenica	---	---	---	7	---	---	---	---	---	---	---	---	---	---	---
Foleyella candezei	---	---	---	---	---	---	---	8	8	---	---	---	---	---	---
Moaciria icosiensis	---	---	---	---	---	---	---	---	---	---	11	---	---	---	---
Oswaldocruzia filiformis	---	---	---	7	1	1	---	---	---	---	---	---	---	---	---
Oswaldocruzia skrjabini	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Oxysomatium brevicaudatum	1	---	----	---	---	---	---	---	---	---	---	---	---	---	---
Pharyngodon mamillatus	---	---	---	---	---	---	---	---	---	---	11	---	---	---	---
Pharyngodon inermicauda	---	---	---	---	---	---	---	---	---	---	11	---	---	---	---
Parapharyngodon bulbosus	---	---	---	---	---	---	---	---	---	---	11	---	---	---	---
Parapharyngodon kasauli	---	---	---	---	---	1	---	8	---	---	---	---	---	---	---
Parapharyngodon tyche	---	---	---	---	---	---	---	8	8	---	---	---	---	---	---
Parapharyngodon micipsae	---	2	---	---	---	---	---	---	---	---	---	---	---	---	---
Physaloptera sp. (larva)	---	---	---	---	1	---	---	---	---	---	---	---	---	10	---
Skrjabinodon medinae	---	---	---	7	---	---	---	---	---	---	---	---	---	---	12
Skrjabinodon aegyptiacus	---	---	---	---	---	---	---	---	---	---	11	---	---	---	---
Skrjabinelazia hoffmanni	---	---	---	7	---	---	---	---	---	---	---	---	---	---	---
Skrjabinelazia taurica	---	---	----	---	---	1	---	---	---	---	---	---	---	---	---
Spauligodon sp.	---	---	----	---	---	---	6	---	---	---	---	---	---	---	---
Spauligodon atlanticus	---	---	----	---	---	---	---	---	---	---	---	---	---	---	12
Spauligodon eremiasi	---	---	---	---	---	---	---	---	---	---	---	---	10	10	---
Spauligodon laevicauda	---	---	3,4,5	---	---	---	---	---	---	---	---	---	---	---	---
Spauligodon saxicolae	---	---	----	---	---	---	---	---	---	---	---	---	10	10	---
Spinicauda sonsinoi	---	---	---	---	---	---	---	---	---	---	11	---	---	---	---
Strongyluris calotis	---	---	---	---	---	---	---	8	---	---	---	---	---	---	---
Thelandros baylisi	---	---	---	---	---	---	---	---	8	---	---	---	---	---	---
Thelandros taylori	---	---	---	---	---	---	---	8	---	---	---	---	---	---	---
Thelastomoides sp.	---	2	---	---	---	---	---	---	---	---	---	---	---	---	---
Acanthocephala															
Macracanthorhynchus catulinus	--	---	5	---	---	---	----	---	---	---	---	---	---	---	---
Acanthocephal cystacanth stage	---	---	---	---	---	---	---	---	---	---	---	10	---	---	---
Centrorhynchus sp.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	12

The infection sites included the large intestine (rectum), small intestine, body cavitiy and caecum. *S. atlanticus* was the most prevalent species, followed by *S. medinae*. Infection prevalence, abundance and mean intensity of the parasites in *A. cappadocica* were given in Table 1.

Discussion

Total of 5 helminth species was found (2 Nematoda, 2 Cestoda, and 1 Acanthocephala). A total of 235 helminths were collected from 21 (67 %) of the 31 lizards examined, 5 helminth species were present in our survey; however, no host harboured more than 3 helminth species. The majority of infected lizards harboured only one helminth species; 11 lizard samples (52 %) harbored 1 species of helminth; 7 lizard samples (33 %) harbored 2 species; 3 lizard samples (14 %) harboured 3 species. There were 1.62 ± 0.16 (X ±1 SE) helminth species per infected lizard samples and 11.19 ± 2.81 helminth individuals per infected lizard samples.

A. cappadocica represents a new host record for each of the parasite species. *S. atlanticus* is reported from Turkey for the first time. All of these parasites species excluding *S. atlanticus* were previously reported from different lizards in Turkey (Table 2).

To our knowledge, there are no reports of helminths in *A. cappadocica* in the World.

In our study, male samples of *A. cappadocica* were more heavily infected by nematodes than female samples; the largest numbers of nematodes occurred in the caecum and large intestine.

Mesocestoides sp. was found in larval stages. This suggests that the *A. cappadocica* may be intermediate or paratenic hosts of this species. The ultimate host is presumably a predator of the lizards (possibly a bird or a mammal). The life cycle of *Mesocestoides* sp. 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). Tetrathyrida is frequently found in the body cavities of amphibians, reptiles, and rodents (Padgett & Boyce, 2004). In our study, a total of 42 tetrathyrida were collected from 3 of 21 infected host lizard (14 %). *A. cappadocica* represents third host record for the genus *Mesocestoides* from Turkey. The first report of this genus was in the *Lacerta trilienata* from Bursa, Turkey (Yıldırımhan *et al*., 2011) and the second report was *Anatolalacerta danfordi* from western Turkey (Gürelli *et al*., 2007).

Some 85 species have been assigned to *Oochoristica*, a cosmopolitian genus of cestodes parasitic in reptiles, but because most species have not been recorded since their description, the number of species is questionable (Schuster, 2011). Bursey *et al*. (2010) list 17 species from the Palaearctic region. In our study, this species was observed only one host (4,76 %). This species was reported from *Paralaudakia caucasica* (Yıldırımhan *et al*. 2006), *Lacerta trilineata* (Yıldırımhan *et al*., 2011) and *Chalcides ocellatus* (Incedogan *et al*., 2014) from several localities in Turkey.

There are currently 47 nominal species of *Spauligodon* that occur in lizards assigned to the Agamidae, Chamaeleonidae, Gekkonidae, Lacertidae, Opluridae, Phrynosomatidae, Polychroticae, Scincidae, Teiidae and Tropiduridae. Of these 20 are found in the Palearctic realm. (Bursey & Goldberg, 2011).

Species of *Spauligodon* are distinguished on the basis of the presence or absence of a spicule the presence or absence of spines on the tail filament of adults, egg morphology and geographical distribution (Bursey *et al*., 2005). In our study, the pharyngodonid nematode found was *S.atlanticus* being the dominant helminth in all localities. This species was observed in 14 of 21 infected host lizard (66 %). A total of 87 parasite were collected from 14 host lizard. *S. atlanticus* from Turkey was reported for the first time.

The pharyngodonid nematode found was *Skrjabinodon medinae* being the second dominant helminth in all localities. It was described by Garcia-Calvente (1948) as *Pharyngodon medinae*. This species was recorded in 13 of 21 host lizard (61 %). A total of 100 parasite collected from 11 host lizard. *S. medinae* was recorded from *Lacerta trilineata*, Bursa province from Turkey (Yıldırımhan *et al*., 2011). So this is the second report from Turkey for this helminth species.

The acanthocephalans are distributed worldwide, and several reports on the presence of acanthocephalans had existed from lizards in Turkey (Yıldırımhan *et al*., 2008; Düsen *et al*., 2013). In this study, we reported as larvae of *Centrorhynchus* sp., However, the detailed species identification was not possible due to the absence of adult worms. Since the adults of this genus are known to be parasitic in birds, an experimental infection in birds is needed for species identification. Their intermediate hosts are terrestrial isopods or insects, Orthoptera or Coleoptera, and their various paratenic hosts, amphibians, reptiles, and mammals, play a fundamental role in their transmission to the birds (Buron & Golvan, 1986). Amphibians and reptiles serve as paratenic hosts for some acanthocephalan species that mature in flesh-eating birds, and species of *Centrorhynchus* are known to be present in frogs, lizards and snakes. *Centrorhynchus* is the largest acanthocephalan genus having almost 90 species, and these are parasites mainly of birds of the orders Falconiformes and Strigiformes (Choi *et al*., 2010). In our study, this species was observed in 3 of 21 infected host lizard (14 %). A total of 5 parasites collected from 3 host lizard. There is only one species from Turkey for this genus. *Centrorhynchus amphibius* was recorded from *Buteo buteo*, Bursa province from Turkey (Tezel *et al*., In press).

Helminth species have been classified as core and secondary species according to their prevalence (P): species with prevalence >30 % redeemed core species and species with 10 – 30 % prevalence is considered secondary species (Roca, 1993). In this survey *S. atlanticus* and *S. medinae* represent core species, *Mesocestoides* sp., *Oochoristica tuberculata*, *Centrorhynchus* sp. represent secondary species. Helminths infecting *A. cappadocica* are generalists and commonly found in European reptiles.

The low values of prevalence and mean intensities of infection (Tables 1) indicate that many members of the helminth infracommunities occurred only irregularly and occasionally. This agrees with the typical pattern of helminth infection in many reptiles, i.e. few species occur frequently, few species occur with moderate prevalence, and many species are rare (Aho 1990; Roca & Hornero 1994).

Although several recent ecological studies are available on helminth communities of reptiles (Dobson *et al*., 1992), there is a paucity of data on the structure of the helminth communities of European reptiles (Roca & Homero, 1994; Roca, 1995; Sanchis *et al*., 2000). Moreover, the structure of helminth communities in reptiles from the Palaearctic region has received little attention at

both hierarchical levels of organization, the infracommunity and the component community. In Turkey, there is little knowledge available on the helminth fauna of lizards. At the present, studies of helminth fauna of lizards have been still scarce, incomplete and mainly from the point of view of taxonomy of parasites. Thus, additional studies will be required before the component community of helminths infecting Turkish lizards can be determined. A summary of known Turkish lizard helminths is presented in the Table 2.

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