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Helminth fauna of Lebanon Lizard, *Phoenicolacerta laevis* (Gray, 1838), (Squamata: Lacertidae) from Southern Turkey

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Summary

In the years 2010 and 2014, fifty-four samples of *Phoenicolacerta laevis* from eight localities in Adana (n=6) and Hatay (n=48) were collected and examined for helminth parasites. New host and locality records were recorded. As a results of present study, three species of Digenea, *Sonsinotrema tacapense*, *Prosthodendrium chilostomum*, *Brachylaima* sp. (metacercaria); two species of Cestoda, *Oochoristica tuberculata* and *Mesocestoides sp.* and four species of Nematoda, *Skrjabinodon medinae*, *Spauligodon* sp., *Thubunaea sp.* and a larva of the Ascaridiidae *Ascarididae* gen. *sp.* were reported for lizard samples. We document new host records for all of helminth species reported here. *Sonsionotrema tacapense* (Digenea), and *Thubunaea sp.* (Nematoda) are recorded for the first time from Turkey. There are, to our knowledge, no reports of helminths for *P. laevis* in Turkey and also from its range.

Keywords: *Phoenicolacerta laevis*; Digenea; Cestoda; Nematoda; helminth; Turkey

Introduction

Turkey is situated in junction point of fauna unit from several different origins and has 157 amphibia and reptilia species with as rich as continental Europe (Baran & Atatür, 1998; Baran *et al.,* 2012). However, the literature dealing with the parasitic fauna of the Turkey still contains little information on helminths of lizards. Reptiles are commonly infected by a wide range of parasites, serving either as their definitive or intermediate hosts (Azhar, 2010). However, despite the great diversity of the Lacertidae lizards relatively few species have been surveyed for helminths.

Across the world, there are several studies on helminth fauna of some Lacertid lizards especially from Palearctic region. These species and localities are; *Lacerta agilis* from Poland (Lewin, 1992a) and *Zootaca vivipara* (Lewin, 1992b), *Lacerta agilis* from Palaearctic (Sharpilo *et al.,* 2001); *Lacerta viridis* from Bulgaria (Biserkov & Kostadinova, 1998); *Lacerta viridis* and *Podarcis muralis* from Bulgaria (Kirin, 2002), *Podarcis pityusensis* from Spain (Hornero & Roca, 1992), *Lacerta schreiberi* from Spain (Roca & Ferragut, 1989); *Podarcis pityusensis* and *Podarcis lilfordi* from Spain (Roca & Hornero, 1994), Lacertidae family from Spain (Roca & Lluch, 1988), *Lacerta agilis* from Romania (Mihalca *et al.,* 2007), *Podarcis bocagei* and *Podarcis carbonelli* from Portugal (Galdon *et al.,* 2006), *Zootaxa vivipara* from Spain (Sanchis *et al*., 2000), *Gallotia caesaris gomerae* and *Gallotia caesaris caesaris* from Spain (Martin & Roca, 2004), *Podarcis vaucheri* from Algeria (Carretero *et al.,* 2011). There are some helminth parasite studies in Turkey especially for lacertid lizards. These species are European Green Lizard, *Lacerta viridis* (Schad *et al.,* 1960); Crimean Wall Lizard *Podarcis tauricus* (Schad *et al.,* 1960); Dwarf Lizard, *Parvilacerta parva* (Saygı & Olgun, 1993); Danford's Lizard, *Anatololacerta danfordi* (Gürelli *et al.,* 2007), Balkan Emerald Lizard, *Lacerta trilineata* (Yıldırımhan *et al.,* 2011); Pleske's Racerunner-Transcaucasian Racerunner, *Eremias pleskei,* Strauch's Rac-

erunner*, Eremias strauchi,* Suphan Racerunner, *Eremias suphani* (Düsen *et al.* 2013), Anatolian Lizard, *Apathya cappadocica*, (Birlik *et al.,* 2015), Spiny-Tailed Lizard, *Darevskia rudis* (Roca *et al.,* 2015a), and Uzzel's lizard *Darevskia uzzelli*, Bendimahi Lizard *D. bendimahiensis* and Van Lizard *D. sapphirina* (Roca *et al.,* 2015b). Lebanon lizard *Phoenicolacerta laevis* occurs in southern and western Turkey (Vilayets Hatay, Adana, Mersin, Kahramanmaraş, Osmaniye, Antalya, Muğla and İzmir), western Syria, throughout Lebanon (where widespread, including on Palm Island), northern Israel and northwestern Jordan (Ilgaz *et al.,* 2016). It has a plumped body with a total length up to 25 cm. Head and body is flattened dorso-ventrally. The ground color of dorsum is greenish brown with dark markings. The chin and neck are red or yellowish-red color in spring (Baran & Atatür, 1998; Baran *et al.,* 2012). It is found up to 1,800 m above sea level (asl). In suitable habitats, the population density is so high. This reasonably adaptable species is found in rocky forested areas, in meadows, in gardens, on walls of houses and in orchards. It is an egg-laying species. The species prefers humid habitats in oak forests, gardens and valleys. More recent, Tamar *et al.* (2015) conducted the most compressive molecular study based on both mitochondrial and nuclear gene fragments (covering 12S rRNA, cytb, MC1R and ACM4) on genus *Phoenicolacerta*. They found high levels of undescribed diversity within *P. laevis* which necessitate a thorough revision but did not do any taxonomical rearrangement. For that reason, we can accept the host species used in the present study as *P. laevis* now.
Recently, studies of helminth parasites from lizards have been started to increase gradually in defined geographical areas but studies on helminth fauna of lizards of the genus *Phoenicolacerta* are partial and scarce, none for *P. laevis*. Thus, this work represents an opportunity to know for the first time helminth communities parasitizing *P. laevis* from Turkey.

Material and Methods

In November 2010 and between April and May 2014, 54 *P. laevis* (24♀, 31 ♂) mean snout-vent length = 68,57 ± 11,46 mm, with a range from 46.0 to 87.0 mm, were collected by hand from Hatay and Adana, Turkey: Kırıkhan- Hatay (36°29'N, 36°21'E, 151 m elevation, on 2 November 2010, n=19), Döver Village, Harbiye, Hatay (36°06'N, 36°07'E, 251 m elevation, on 2 May 2014, n=12), Yenişehir Lake, Reyhanlı, Hatay (36°14'N, 36°34'E, 179 m elevation, on 1 May 2014, n=1), Ceylanlı, Kırıkhan, Hatay (36°33'N, 36°21'E, 401 m elevation, on 1 May 2014, n=1), Çevlik, Samandağ, Hatay (36°07'N, 35°55'E, 28 m elevation, on 2 May 2014, n=11), Delibekirli Village, Kırıkhan, Hatay (36°32'N, 36°19'E, 550 m elevation, on 1 May 2014, n=4), Köleli Village, Feke, Adana (37°48'N, 35°54'E, 557 m elevation, on 21 April 2014, n=2), Dağılcak Recreation Area, Kozan, Adana (37°32'N, 35°50'E, 305 m elevation, on 17 April 2014, n=1), Gedikli Village, Kozan, Adana (37°30'N, 35°52'E, 398 m elevation, on 27 April 2014, n=3).
The body cavity was opened, and the digestive tract removed. The oesophagus, stomach, small and large intestine and lungs were opened and separetly examined for helminths under a dissecting microscope. 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. Digeneans and 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. Parasites were identified, where possible, to species, and the number and location of individuals of each species were recorded. Helminth identification was based on keys given by Schmidt (1986), Petter & Quentin (1976), Yorke & Maplestone (1926), Yamaguti (1961), Baker (1987), Bray *et al.* (2008). Helminth voucher specimens were deposited in the helminth collection of Uludag University Science and Art Faculty, Department of Biology, Bursa, Turkey.

Results

Nine species of helminth parasites were detected in Lebanon Lizard. These species were 3 species of Digenea, *Sonsinotrema tacapense*, *Prosthodendrium chilostomum*, *Brachylaima* sp. (metacercaria); two species of Cestoda, *Oochoristica tuberculata* and *Mesocestoides* sp. and four species of Nematoda, *Skrjabinodon medinae*, *Spauligodon* sp., *Thubunaea* sp. and a larva of the Ascaridiidae *Ascarididae* gen. sp. Of 54 *P. laevis* 33 (61 %) were infected with one or more parasites. Of 54 host lizard 21 (38 %) were infected by any parasite species. Total 278 individuals of nine parasite species were collected from 33 of the 54 Lebanon lizards examined. Of these, three (9 %) were larval forms not capable of reaching maturity in lizards. There were nine helminth species represented in the lizards but no individual host harbored more than three helminth species. Of the infected lizards, 24 harbored one species of helminth; six harbored two species and three harbored three species. There were 7.72 ± 0.88 (x ± SE) helminth species/infected lizard.
Infection prevalence, abundance and mean intensity of the parasites in *P. laevis* were given in Table 1. More than 45% of the total helminths found belong to a single species, *Prosthodendrium chilostomum* (Digenea), followed by *Skrjabinodon medinae* 36% (Nematoda). All helminths found in *P. laevis* are new host records.

Digenea: Brachylaimidae
***Brachylaima* Dujardin, 1843**
***Brachylaima* sp. (metacercariae)**
Species of *Brachylaima* are parasites that often exhibit a triheteroxenous terrestrial life cycle in which molluscs serve as first and second intermediate hosts and amphibians and reptiles may harbor unencysted metaceraria, before reaching the definitive hosts, birds and mammals. Adults are parasites of the small intestine of birds and mammals (Yamaguti, 1958) metacercaria in Reptilia (Roca *et al*., 1989, Roca & Hornero, 1994; Galdon *et al*., 2006; Roca *et al*., 2006). We found this species in only one infected host lizard (3 %) from Hatay province. A total parasite number of this

Table.1 Prevalence, mean intensity and mean abundance of helminth species found in lizards

Helminth species	Site of infection	Prevalence (%)	Mean intensity	Mean abundance
Digenea				
Sonsinotrema tacapense	small intestine	1.85	7	0.12
Prosthodendrium chilostomum	small intestine	7.40	31.75	2.35
Brachylaima sp.	small intestine	1.85	1	0.01
Cestoda				
Mesocestoides sp. (larvae)	body cavity	1.85	1	0.01
Oochoristica tuberculata	small intestine	3.7	2.5	0.09
Nematoda				
Spauligodon sp.	caecum	16.6	3.11	0.5
Skrjabinodon medinae	large intestine	48.14	3.88	1.87
Thubunaea sp.	stomach	1.85	7	0.12
Ascarididae gen. sp.	small intestine	1.85	1	0.01

species was one. Acccording to the literature, this is the third report of metacercaria of *Brachylaima* from Turkey; Other reported hosts: *Lacerta trilineata* (Yıldırımhan *et al.,* 2011) and *Chalcides ocellatus* (Incedogan *et al.,* 2014). *P. laevis* represents a new host record for the genus *Brachylaima.*

Trematoda: Lecithodendriidae

***Sonsinotrema tacapense* (Sonsino, 1894) Balozet & Callot, 1938**

Specimens of this digenetic trematode were detected in the small intestine of *P. laevis* from only one of the localities studied. A total parasite number were seven in one host from Kırıkhan, Hatay province. There are no reports from Turkey for this species. This is the first report of *S. tacapense* from Turkey. *P. laevis* is a new host record for this species.

***Prosthodendrium chilostomum* (Mehlis, 1831)**

Lecithodendriid flukes form the bulk of the intestinal parasites of bats, and of these, a large part belong to the genus *Prosthodendrium* Dollfus, 1931. This trematode attained sexual maturity in its intermediate host. It was reported from *Lacerta viridis* and *Zootaca vivipara* (Sharpilo, 1976) from Ukraine. There are no reports from Turkey for this species. We found this species in the small intestine. A total parasite number were 120 in four hosts from Hatay province. This is the first report of *P. chilostomum* from Turkey. *P. laevis* is a new host record for this species. The most abundant helminth that was found parasitizing *P. laevis* was *Pr. chilostomum*, with a mean intensity of 31.75 parasites per host.

Cestoidea

Cyclophyllidea: Mesocestoididae

***Mesocestoides* sp. Vaillant, 1863**

Adults are parasites of birds and mammals, and according to Witenberg (1934) the first mention of tetrathyridium as accidental or paratenic parasites of lizards was *Lacerta viridis* and *Podarcis muralis* listed by Rudolphi (1819). The genus *Mesocestoides* is cosmopolitan (Schmidt, 1986). Tetrathyrida is frequently found in the body cavities of amphibians, reptiles, and rodents (Padgett & Boyce, 2004).

In our study, only one tetrathyrida was collected from one of 33 infected host lizard (3%). *P. laevis* represents fourth host record for the genus *Mesocestoides* from Turkey. The first report of this genus was in the *Lacerta trilineata* from Bursa, Turkey (Yıldırımhan *et al.,* 2011). The second report was *Anatolalacerta danfordi* from

Western Turkey (Gürelli *et al.,* 2007). The third report was *Apathya cappadocica* from Turkey (Birlik *et al.,* 2015). *P. laevis* represents new host record for tetrathyridia of *Mesocestoides.*

Cestoidea
Cyclophyllidea: Anoplocephalidae
Oochoristica tuberculata
(Rudolphi, 1819) Lühe, 1898
In our study, this species was observed in only two hosts (6%). This species was reported from *Paralaudakia caucasia* (Yıldırımhan *et al.,* 2006), *Lacerta trilineata* (Yıldırımhan *et al.,* 2011), *Chalcides ocellatus* (Incedogan *et al.,* 2014) and *Apathya cappadocica* (Birlik *et al.,* 2015) from several localities in Turkey. This report is the fifth for *O. tuberculata* from reptiles in Turkey. We document herein a new host record for *O. tuberculata,* the first report of a cestode parasite from *P. laevis*.

Spirurida: Physalopteridae
***Thubunaea* Seurat, 1914**
***Thubunaea* sp.**
According to Bursey & Goldberg (1991) there are at present 17 species of *Thubunaea* including the parasites of reptiles. Adult worms are found in the stomach or intestine of lizards and snakes. The physalopterines are usually found firmly attached to the gastric mucosa with the aid of large dentate pseudolabia and a collarette which presses into the mucosa. There is only limited information on species in reptiles. In our study, only female specimens have been found. So this specimen was identified at a genus level. When males are found, the length of the spicule, in association with other morphometric data, is a useful comparative character for specific identification.
We found this parasite species in only one host lizard (1.85%) from Samandağ, Hatay province. A total parasite number of this parasite species was seven. Acccording to the literature, there are no records of *Thubunaea* sp. from Turkey. This helmint species is a new helmint record for Turkey. Also, *P. laevis* is a new host record for *Thubunaea* sp.

Oxyurida: Pharyngodonidae
***Skrjabinodon* (Inglis, 1968)**
***Skrjabinodon medinae* (Garcia Calvente, 1948)**
Skrjabinodon medinae is a cosmopolitan parasite of reptiles (Inglis, 1968; Petter & Quentin 1976). Small cylindrical nematodes, evident sexual dimorphism, males approximately one-fourth length of female. Lateral alae present in males, absent in females. Females with vulva near esophageal bulb. Several morphological characteristics noted by different authors (Skrjabin *et al.,* 1960; Inglis, 1968; Petter & Quentin 1976), as last pair of papillae not rosette-shaped and the absence of caudal alae in the male, indicate the genus *Skrjabinodon* Inglis, 1968. *S. medinae* posseses four pairs of cloacal papillae, including two pairs of postcloacal papillae (Hornero & Roca 1992).
We found this parasite species in twenty-six infected host lizards (78%) from Adana and Hatay provinces. More than 35% of the total helminths found belong to *Skrjabinodon medinae*. This species was the second most abundant helminth that was found parasitizing *P. laevis* with a prevalence of 48.14% and a mean intensity of 3.88 parasites per host.
A total parasite number of this parasite species was 101. Both male and female specimens have been found. Acccording to the literature, two species of *Skrjabinodon* Inglis, 1968 have been reported previously from reptiles of Turkey. These species and hosts are *Skrjabinodon medinae* from *Lacerta trilineata* (Yıldırımhan *et al.,* 2011), *Sk. aegyptiacus* from *Chalcides ocellatus* (Incedogan *et al.,* 2014). This species was reported from *Apathya cappadocica* (Birlik *et al*., 2015). This is the third report for *Sk. medinae* from Turkey. *P. laevis* is a new host record for *S. medinae*.

Ascaridida: Heterakoidea
Ascarididae Baird, 1853
(Undetermined larvae)
Ascarididae larvae, genera of the Ascarididae often exhibit unique esophageal characters, which when present can be used to identify a larva. Unique characters are generally absent, and it is impractical to assign such larvae to a genus.
In present study, larval forms of helminths have been found in host lizard. This suggests that this lizard is a useful intermediate host for heteroxenous helminth species.
We found this larvae in only one infected host lizard (3%) from Samandağ, Hatay province. A total parasite number of this larvae was one. Acccording to the literature, Ascarid larva reported from *Stellagama stellio* from Turkey (Yıldırımhan *et al.,* 2006). This is the second report for this parasite and *P. laevis* represent new host record for larvae assigned to the Ascarididae.

Oxyuroidea: Pharyngodonidae
***Spauligodon* Skrjabin, Schikkhobalova and Lagodovskaja, 1960**
***Spauligodon* sp.**
Species of *Spauligodon* are separated on the basis of the presence or absence of a spicule, the appearance of the tail, egg morphology, and geographical distribution.
Currently, 50 species are assigned to *Spauligodon*. Based upon the zoogeographic regions described by Holt *et al.* (2013) eight from the Afrotropical realm, one from the Australian realm, one from the Madagascan realm, seven from the Nearctic realm, three from the Neotropical realm, three from the Oceanian realm, one from the Oriental realm, 16 from the Palaeractic region, five from the Panamanian realm, and five from the Saharo-Arabian realm. Three species have previously been described in which males have aspinose filamentous tails and a spicule absent, and females have spinose filamentous tails and barrel-shaped eggs, namely, *S. atlanticus*, *S. eremiasi*, and *S. occidentalis*. The location of the vulva can be used to distinguish some species. In *S. occidentalis*,

the vulva is anterior to the esophageal bulb. In this study, male specimens have no spicule and aspinose filamentous tail; female specimens have spinose filamentous tail. There are no *Spauligodon* records about prebulbar vulva location from Palearctic up to now. Advanced studies will be needed about this species.

We found this nematode in nine infected host lizard (27%) from Samandağ, Hatay province. A total parasite number of this species was 28. Acccording to the literature, there is one record of *Spauligodon* sp. from Turkey (Saygı & Olgun, 1993). Also, *P. laevis* is a new host record for *Spauligodon* sp.

Discussion

Studies on the community ecology of parasites of European reptiles, and particularly lacertids, have increased in the last years. (Roca *et al.,* 2012). However, there are 66 species of lizards known from Turkey (Uetz, 2015): one species of Phyllodactylidae, five species of Gekkonidae, one species of Eublepharidae, four species of Agamidae, one species of Chamaeleontidae, two species of Anguidae, one species of Varanidae, 39 species of Lacertidae, nine species of Scincidae and three species of Amphisbaenidae. Up to now, only 10 lizard species from Lacertidae have been investigated for helminth fauna in Turkey.

In our study, the helminth fauna of the studied population of *P. laevis* was rich as helminth biodiversity was concerned but was poor as numbers of helminth were investigated. Most helminth species occured at low prevalence. The low value of prevalence and mean intensity of infection indicate that many members of the helminth infracommunities occur only irregularly and occasionally (Martin & Roca, 2005). 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). There is only one core species (prevalence of infeciton 30% or higher) in helminth population (*Skrjabinodon medinae* with a prevalence 48.17) so only the *Sk. medinae* appears to be a common parasite of *P. laevis*. This agrees with the typical pattern of helminth infection in many reptiles, i.e., few species occur frequently, few species occur moderate prevalence and many species are rare (Aho, 1990; Martin & Roca, 2005). The remaining helminth species can be considered as a secondary species of *P. laevis.* The low richness of helminths and the low prevalence and infection rates found for *P. laevis* might be related to the diet. Our results confirm previous findings, suggesting that small carnivorous reptiles harbor poorer helminth communities than herbivorous ones (Petter & Quentin, 1976; Martin *et al.,* 2005; Carretero *et al.,* 2006).

In our study, especially for some helminth species obtained from host lizard -for example *Thubunaea* sp.- if male specimens are found, it will be identified at species level in next studies. It will be same for Ascarididae, too (undetermined larvae).

In summary, we have documented nine new host and four new distributional records for helminths of *P. laevis*. *P laevis* represents a new host record for each of the parasite species. Two helminth species are reported from Turkey for the first time. We suspect that with additional surveys, particularly those carried out other parts of its range where studies are lacking, additional host and distributional records for its parasites will be potentially reported.

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