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DOI 10.2478/helm-2024-0035

HELMINTHOLOGIA, 61, 4: 360 – 367, 2024

Research Note

Helminth fauna of *Anatololacerta pelasgiana* (Mertens, 1959) (Sauria: Lacertidae) from several localities of south-west part of Türkiye

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Article info

Received August 12, 2024
Accepted December 6, 2024

Summary

We present data on helminths harboured by Pelasgian Rock Lizard *Anatololacerta pelasgiana* (Mertens, 1959) from several localities in Muğla province, Türkiye. Five helminth species (Nematoda) were found in *A. pelesgiana*: *Oswaldocruzia filiformis*, *Physalopteroides* sp., *Thubunae* sp., *Spauligodon cabrerae* and *Spauligodon aloisei.* Overall helminth prevalences were not relatively high for this species [27/44 (61.3 %)]; helminth assemblages from host species were depauperate and dominated by generalist helminths with direct life cycles.

Keywords: *Anatololacerta pelasgiana*; helminth; parasite; Nematoda; Türkiye

Introduction

The genus *Anatololacerta* Arnold, Arribas & Carranza, 2007 (Lacertidae) is predominantly distributed across Anatolia, encompassing western and southern regions of Türkiye, as well as the Aegean islands of Nisyros, Symi, Tragousa, Rhodes, Pentanisos, Kastellorizo, Tilos and Chalki (Karakasi *et al*., 2021). The Pelasgian Rock Lizard, *A. pelasgiana* (Mertens, 1959) is a diurnal species that feeds on invertebrates, mainly insects (Valakos *et al*., 2008). The species prefers cultivated lands with dry-stone walls, rocky areas, and light deciduous forests. It is known from Southwestern Anatolia and the Greek islands Nisyros, Symi, Tragousa, Rhodes, Pentanisos, Kastellorizo, Tilos and Chalki (Karakasi *et al*., 2021).
Recent studies have contributed to our understanding of the helminth faunas of reptiles (Roca, 2021; Silva *et al*., 2023; Oitaven *et al*., 2023; However, there is still a significant lack of knowledge on helminths from reptiles distributed in Türkiye, and considering existing information on parasites from lizards, the number of species known to parasitize these animals is proportionally lower than that of other animal groups This may be due to a shortage of surveys of their helminth fauna (Ávila & Silva, 2010).

Data on the endoparasite faunas associated with lizards of this genus were, until recently, limited to reports of *A. danfordi* (Günther, 1876) (Gürelli *et al*., 2007) and *A. anatolica* (Werner, 1900) (Yıldırımhan *et al*., 2020a; Sümer *et al*., 2023). However, there is as yet no data on the helminth fauna of *A. pelasgiana*.
In the present study, data is provided on the helminth fauna of *A. pelasgiana* collected from different localities in Muğla Province, Türkiye.

Materials and Methods

The lizards were collected from several localities in Muğla province, southwestern Türkiye in 1991, 1992 and 2013. A total of forty-four were transported to the laboratory. The snout-ventral length (SVL) of each (mean snout-vent length, SVL = 62.88 mm ± 6.04 SD SVL range 45 – 71 mm) was measured and the sex was recorded. Specimens were immediately dissected after being euthanized then transferred to 70 % ethanol for storage in the herpetology collection of the Fauna and Flora Research and Application Center of Dokuz Eylül University.
The gastrointestinal tract and lungs were removed and exam-

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ined for helminths. Nematodes were placed in glycerol on glass slides, cleared, and observed under a light microscope. Voucher helminths were placed in vials of alcohol and deposited in the Parasitology Museum of Bursa Uludağ University.

Parasite species were determined based on Yamaguti, 1961, Skrjabin *et al.* 1960, Moravec and Vojtkova 1974, Baker 1987, Sharpilo 1962, Ben Slimane *et al*. 1993, Anderson *et al*. 2009, Gibbons 2009.

Snout-ventral lengths of infected (n = 27) and uninfected (n = 17) hosts as well as infected with different parasite species were compared by t-test ($p < 0.05$). Parasite infection was compared between sexes by $\chi 2$ test ($p > 0.05$).

Ethical Approval and/or Informed Consent

The result of this work has not been published previously and is not under consideration elsewhere

Results

Morphological analysis of the recovered helminths resulted in the identification of 5 distinct species. Data on these species are given in Table 1. The following species were found and are recorded below as new host records: *Oswaldocruzia filiformis* (Goeze, 1782), *Physalopteroides* sp., *Thubunae* sp., *Spauligodon cabrerae* Castano-Fernandez, Zapatero-Ramos & Solera-Puertas, 1988, *Sp. aloisei* Casanova, Milazzo, Ribas & Cagnin, 2003 first time registered for reptiles in those locations. Additionally, one species of Nematoda (*S. cabrerae*) is a new host record for the helminth fauna of Türkiye.

Amongst forty-four lizard samples (mean SVL 62.88 mm ± 6.04) including 19 females and 24 males, 1 juvenile, 27 (61.3 %) were infected with one or more parasite species. Among the 27 infected specimens, 20 hosts harboured with 1 species of parasite, 4 harboured with 2 species and 3 harboured with 3 species.

Oswaldocruzia filiformis has been reported from lizards and amphibians many times in Türkiye and other countries, highlighting its extensive host distribution (Bursey *et al*., 2005a; Yıldırımhan *et al*., 2006). Lizard hosts: *Anguis colchica* (Düşen *et al*., 2010; Sümer *et al*., 2019); *Darevskia rudis* (Roca *et al*., 2016; Birlik *et al*., 2018; Birlik, 2022); *Anguis fragilis* (Lewin, 1990; Shimalov *et al*., 2000); *L. diplochondrodes* (Yıldırımhan *et al*., 2011); *Darevskia derjugini* (Birlik, 2022); *Lacerta agilis* (Shevchenko & Barabashova, 1958; Moravec, 1963; Sharpilo, 1976; Okulewicz, 1976; Shimalov *et al*., 2000; Kirillov, 2000; Sharpilo *et al*., 2001; Mihalca *et al*., 2007; Kirillov *et al*., 2015; Kirillov *et al*., 2018); *L. viridis* (Schad *et al*., 1960; Biserkov & Kostadinova, 1998; Kirin, 2002; Borkovcova & Kopriva, 2005; Yıldırımhan *et al*., 2020b); *Podarcis tauricus* (Schad *et al*., 1960); *Pseudopus apodus* and *Takydromus vivipara* (Sharpilo, 1976); *Zootoca vivipara* (Markov, 1950; Moravec, 1963; Shimalov *et al*., 2000; Sanchis *et al*., 2000; Kirillov, 2000; Kirillov *et al*., 2015). . This study is the fifth record of Türkiye for *O. filiformis*. Three specimens were found in 2 hosts.

The genus *Physalopteroides* Wu & Liu, 1940 contains 20 species of amphibians and reptiles from Asia, Africa, Central and South America and Australia (Bursey & Goldberg, 2016). The genus is the first record of Türkiye. Other Lizard hosts: *Alopoglossus atriventris* (Goldberg *et al*., 2007); Calotes versicolor (Arya, 1991); Carlia caesius (Goldberg, 2018); Carlia eothen, C. luctuosa, Emoia longicauda, E. tetrataenia, Eugongylus albofasciolatus, E. rufescens, Lamprolepis smaragdina (Goldberg *et al*., 2010); Carlia mysi (Bursey *et al*., 2006); Chlamydosaurus kingii (Jones, 1994); *Tarentola annularis* (Elwasila, 1990*Cyrtodactylus epiroticus (Bursey et al., 2017); Cyrtodactylus philippinicus, Gekko mindorensis (Goldberg et al., 2016); Emoia atrocostata (Bursey & Goldberg, 2016); Emoia atrocostata, E. caeruleocauda, E. jakati, E. obscura, E. pallidiceps, E. physicae, E. popei (Goldberg et al., 2008); Gekko gecko (Reese et al., 2004); Hemidactylus brooki (Goswami et al., 2016); H. mabouia (Sousa et al., 2014; Goldberg et al., 2022); Kentropyx calcarata (Ávila & de Silva, 2009); Lepidodactylus lugubris (Bursey & Goldberg, 2001); Nactus spp. (Goldberg et al., 2021); Nephrurus laevissimus*, *N. levis* (Bursey & Goldberg, 1999); *Sphenomorphus jobiensis* (Bursey *et al*., 2005b)*; Thecadactylus rapicauda*, *Cercosaura ocellata*, *Mabuya bistrata*, *Kentropyx altamazonicus*, *K. pelviceps*, *Tupinambis teguixin* (Bursey *et al*., 2005c); *Ptychozoon kuhli* (Bursey *et al*., 2016).

Table 1. Data about identified helminth species.

Helminth species	Number of infected lizards	Prevalence	Mean intensity	Mean abundance	Total number of helminths
Oswaldocruzia filiformis	2	4.54	1.5	0.06	3
Physalopteroides sp.	6	13.63	2	0.27	12
Thubunae sp.	8	18.18	2.75	0.5	22
Spauligodon cabrerae	3	6.81	6.33	0.43	19
Spauligodon aloisei	18	40.9	5.05	2.06	91
				TOTAL	**147**

Twelve specimens were found in 6 hosts. The genus *Thubunae* was created by Seurat (1914) for *T. pudica* Seurat, 1914, which he obtained from lizards and snakes in North Africa (Bursey & Goldberg, 1991). Four species are known from the Palaearctic region for *Thubunae*. These species; *T. baylisi*, *T. dessetae*, *T. schukurovi* and *T. smogorhewzkii*. Only *T. schukurovi* has been reported from Türkiye (Mutafchiev & Vergilov, 2023). *T. schukurovi* and *T. smogorhewzkii* have no spicules on male specimens while other two species have spicules on male specimens. 22 female specimens were found in 8 specimens of host lizards. No male species have been found so this species was identified as *Thubunae* sp. This report is the fourth one of this parasite species for Türkiye. Other lizard hosts were *Ablepharus chernovi* (Mutafchiev & Vergilov, 2023); *Agama aculeata* (Goldberg & Bursey, 2005); *Ameiva ameiva* (Fabio & Rolas, 1979); *Aspidoscelis communis* (Goldberg *et al*., 2014b); *Calotes versicolor* (Mandal & Sinha, 1989); *Ctenosaura pectinata* (Moravec *et al*., 1997); *Darevskia parvula* (Birlik, 2022); *Eremias velox andAblepharus deserti* (Annaev, 1973); *Furcifer pardalis* (Stets, 2019); *Hemidactylus flaviviridis* (Khera, 1951); *Heremites auratus* (Yıldırımhan *et al.,* 2021); *Lacerta agilis* (Sharpilo, 1966); *Laudakia nupta* (Pazoki & Rahimian, 2014); *Mabuya occidentalis, M. spilogaster, M. striata* (Goldberg & Bursey, 2001); *Microlophus peruvianus* and *M. thoracicus* (Pérez *et al*., 2007); *Phoenicolacerta laevis* (Birlik *et al*., 2016); *Ptenopus garrulus* (Goldberg & Bursey, 2001); *Rhoptropus barnardi* (Goldberg *et al*., 1999); *Sceloporus angustus* (Goldberg *et al.,* 2014a); *S. poinsettii* (Goldberg *et al*., 1993a); *S. jarrovii* (Goldberg *et al*., 1996); *Xantusia riversiana* (Goldberg *et al.,* 1993b); *X. wigginsi* (Goldberg *et al.,* 2015); *Trachylepis acutilabris* (Goldberg & Bursey, 2010); *Trapelus mutabilis* (Harras & Elmahy, 2019); *Urosaurus nigrieaudus* (Goldberg *et al.,* 2003); Twenty-two specimens were found in 8 hosts. *Spauligodon cabrerae,* other lizard hosts were *Podarcis lilfordi* (Castaño-Fernández *et al*., 1988; Hornero & Roca, 1992) and *P. pityusensis* (Roca & Hornero, 1994). Nineteen specimens were found in 3 hosts.

Spauligodon aloisei was reported for the first time in Italy from *Podarcis siculus* (Rafinesque, 1810). It differentiates from other members of this genera using some morphological and metrics characters such as having spines on the tail both male and female; absence of spicules in males, the arrangement of the last pair of caudal papilla and vulva location, egg morphology. The most important character for identifying species is the unique prebulbar vulva location found only in all female species of Palearctic region (Casanova *et al*., 2003). Other lizard hosts were *Anatololacerta anatolica* (Sümer *et al*., 2023); *Darevskia unisexualis*, *D. rudis*, *D. raddei*, *D. armeniaca*, *D. valentini*, *D. derjugini* (Birlik, 2022); *Iranolacerta brandtii* (Birlik *et al*., 2017); *P. siculus* (Casanova *et al*., 2003; Carbonara *et al*., 2023). Ninetyone specimens were found in 18 hosts.

Comprehensive sampling across all continents and experimental studies on host specificity should be conducted. Such an approach could provide valuable insights into the biogeographical distribution of both parasites and hosts, contributing to a deeper understanding of the origins of parasitism in reptiles.Despite the low diversity of the helminth fauna, both nematode species occurred with high prevalence and can be considered as “core” species (Dobson & Pacala, 1992; Bush *et al*., 1997) for the studied *A. pelasgiana* population.

Although this definition implies harm, Smyth (1962) and Esch and Fernández (1993) have stated that whether parasitic organisms are harmful or not is irrelevant to the metabolic concept of parasitism. In the case of helminth parasites eggs are released from the host into the external environment where they hatch and undergo development; subsequent life cycle stages must find their way back into another host. One of the major problems for parasites is for individuals of a particular species to find the correct host to propagate the next generation and complete the life cycle. This problem is related to a statistical aspect of colonization, where parasites face spatial and temporal challenges in transferring from one host to another, which require them to have high reproductive rates or to take advantage of complex ecological associations between successive hosts.

All of the helminth species recorded from the host specimens are monoxenous (i.e. have direct life-cycles), being usually acquired by their hosts via direct ingestion of eggs/larval stages (Anderson, 2000).

Sex differences in ecological interactions, feeding habits and reproductive behaviors that may affect infections to some parasites, must be detected (Smyth & Smyth, 1980). Also, the life cycle of the parasites and intermediate hosts must be mentioned. For example, females are larger than males and need more food. So, females would be more often in the exposure to infestation. Sex, season, breeding, and age can affect the infection of parasites, because of changes in the hormone levels in blood of the host (Smyth & Smyth, 1980).

It is important to note that parasite infection was compared between sexes using the χ^2 test; however, no significant correlation was found. Additionally, snout-vent lengths of infected (n=27) and uninfected (n=17) hosts, as well as infection with different parasite species, were compared by t-test ($p<0.05$). These findings are crucial for understanding the dynamics of parasite infections and for developing control strategies. Future studies should investigate the effects of sex, age, and seasonal changes on parasite infections in more detail and explore the ecological and biological characteristics of different helminth groups.

Furthermore, all identified parasites belong to the phylum Nematoda. These organisms have protective cuticle layers, a flexible and chemically inert exoskeleton, and the ability to enter developmental dormancy and diapause as a survival strategy under adverse conditions, including prolonged food shortages (McSorley, 2003). Diverse reproductive strategies also allow nematodes to reproduce rapidly under changing and extreme environmental conditions (Schratzberger *et al*., 2019). Nematodes are organisms characterized by broad ecological adaptability, evolutionary flex-

ibility and rapid reproductive rates, allowing them to dominate in diversity and abundance within their hosts. Other helminth groups may have limited ability to survive and reproduce in these hosts.

Discussion

Of the 75 Turkish lizard species (Baran *et al*., 2021; Yaşar *et al*., 2021), helminth lists are currently available for 41. This investigation represents a pioneering study in identifying the helminth fauna of *A. pelasgiana*. Notably, for all identified helminth parasite species, the host lizard species represent new host records. Furthermore, the identification of *S. cabrerae* constitutes a novel record for Türkiye. These findings significantly contribute to the understanding of helminth diversity and distribution within Turkish herpetofauna, emphasizing the importance of ongoing parasitological investigations**.**

Conflicts of interests

Authors state no conflict of interest.

Acknowledgement

We would like to thank the graduate students of the Biology Department of the Faculty of Science at Dokuz Eylül University for their technical and scientific support during this study.

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