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Helminths of reptiles from Southern Uzbekistan

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In the present study, the results of research on endoparasites of reptiles in Southern Uzbekistan are discussed. As a result of the investigations, 37 species of helminths belonging to 3 phyla, 4 classes, 8 orders, 17 families, and 27 genera were recorded in the reptiles. Among them, 26 species were found in the adult stage, while 10 species occurred in the larval stage. The nematode of the genus *Pseudabbreviata* sp. could not be identified to the species level. Out of 366 examined reptile specimens, 86 individuals (23.5%) were found to be infected with helminths. It was revealed that the class Trematoda was represented by 5 species (13.5%), Cestoda by 6 species (16.2%), Acanthocephala by 1 species (2.7%), and Nematoda by 25 species (67.6%). The number of helminth species in different reptile hosts ranged 1 to 11, with the highest species diversity recorded in the dice snake (*Natrix tessellata*). The occurrence of helminths varied among different reptile suborders. In the representatives of the suborder Cryptodira, 2 nematode species (*Atractis dactyluris* and *Atractis emilii*) were recorded, which are considered specific parasites of tortoises. In the suborder Lacertilia, 24 helminth species were found, 75.0% of which belonged to the class Nematoda. In the suborder Serpentes, 16 helminth species were identified, of which 50% were nematodes. The species *Telorchis assula*, *Macrodera longicollis*, *Oochoristica fedtschenoi*, *Rhabdias fuscovenosus*, *Strongyloides mirzai*, *Polydelphis attenuata*, *Amplicaecum schikhobalovi*, and *Pharyngodon mamillatus* were recorded as specific parasites of snakes. Based on the life cycle characteristics, it was determined that out of the 37 helminth species recorded, 24 species (64.8%) were heteroxenous, while 13 species (35.1%) were monoxenous. These findings expand the knowledge of reptilian helminth biodiversity in Uzbekistan and highlight their importance in epizootology and parasite transmission.

Keywords: parasites; helminths; Trematoda; Cestoda; Acanthocephala; nematoda reptiles; Cryptodirae; Lacertilia; Serpentes; Uzbekistan.

Introduction

Reptiles constitute a significant and diverse ecological group of vertebrate animals in the biocenoses of Uzbekistan. In terms of geographical distribution, they surpass other terrestrial vertebrates, consuming large numbers of insects and rodents and serving as prey for some mammals and birds of prey. Sixty species of reptiles have been recorded in Uzbekistan's biocenoses (Shernazarov et al., 2004), participating in the life cycles of many helminth species. Acting as definitive, intermediate, or reservoir hosts, they facilitate the widespread transmission of helminth infections among wild and domestic animals. Their involvement in the life cycles of helminths reflects a biocenotic interaction with other components of the ecosystem and plays a significant role in the epizootiology of helminthiases.

Globally, published surveys report reptilian helminth faunas ranging tens to over a hundred species per region, with nematodes frequently representing the most species-rich group (Avila & Silva, 2010). Recent large-scale surveys have highlighted a remarkable diversity: for example, 106 helminth species were reported from reptiles in Peru (Cuellar et al., 2022), while 52 species were documented in Iran (Sazmand et al., 2024). By contrast, the data from Central Asia remain limited, and although some studies have been carried out in different regions of Uzbekistan, the helminths of reptiles in the southern part of the country have never been systematically examined. This paucity of research creates a significant gap in understanding of the biodiversity and parasite-host relationships of reptiles in arid ecosystems of Southern Uzbekistan.

In addition to biodiversity considerations, the study of reptilian helminths has veterinary and public health significance. Reptiles often act as reservoirs or paratenic hosts of zoonotic parasites that may infect domestic animals and, in some cases, humans (Mendoza-Roldan et al., 2020; Dusen et al., 2013). The circulation of heteroxenous helminths, which require intermediate hosts such as mollusks or arthropods, is especially sensitive to environmental changes. Therefore, monitoring helminth infections in reptiles not only contributes to faunal inventories but also provides important insights into the ecological balance of local ecosystems and the potential risks for cross-species parasite transmission.

In Central Asia, particularly in Uzbekistan, studies on the species composition of reptilian helminths, as well as their morphological and ecological characteristics, epizootology, and developmental biology, have been conducted by Shakarboev et al., (1999), Ikromov & Azimov (2003), Ikromov & Cho (2004), and other researchers. However, these works are fragmentary and often limited to individual host species. Thus, the overall helminth fauna of reptiles in Southern Uzbekistan remains poorly known.

The objective of the study was to determine the species composition of helminths and the nature of infections in twenty-five species of

reptiles, as well as to identify the specific characteristics of individual reptile suborders under the conditions of Southern Uzbekistan.

Materials and methods

The scientific research on reptile helminths was conducted in Southern Uzbekistan between 2010 and 2022. The helminthological materials were collected from Surkhandarya (Termez, Kumkurgan, Jarkurgan, Sherabad, and Shurchi districts) and Kashkadarya (Dekhkanabad, Nishan, Guzar, Mubarek, Yakkabag, Kamashi, Kasbi, Chirakchi, and Kasan districts) regions. The research was conducted using both stationary and transect (route) methods (Fig. 1).

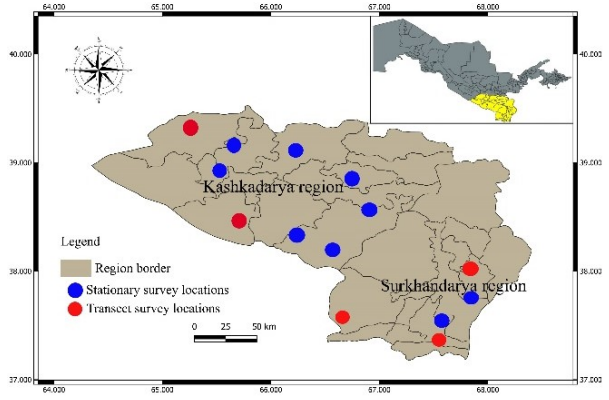

Fig. 1. Map of the study area

A total of 366 reptile specimens were examined using the complete helminthological dissection method. This included individuals that had been run over by vehicles on roads or killed by villagers or domestic animals (Table 1). Reptiles were collected in all seasons, both during the day and at night. Nocturnal lizards (the family Gekkonidae) were captured using electric flashlights. During hibernation, reptiles were located in rodent burrows, loose sand, cracks, cavities, cliffs, old fortress walls, and other wintering shelters. The study was conducted in compliance with ethical standards for the humane treatment of animals in accordance with the recommended standards described in the Directive of the European Parliament and European Council on the protection of animals used for scientific purposes (EU Directive 2010/63/EU) as of September 22, 2010 (Kirillov & Kirillova, 2021).

The reptiles were identified by specialists from the Department of Zoology at Karshi State University and the Laboratory of Vertebrates of the Institute of Zoology of the Academy of Sciences of the Republic of Uzbekistan.

Collection, fixation, and processing of helminths were carried out according to standard methods (Bykhovskaya-Pavlovskaya, 1985; Anikanova et al., 2007) at the Laboratory of General Parasitology of the Institute of Zoology. To express the degree of infection of the reptiles with helminths, indicators generally accepted in parasitology were used: the prevalence of infection (P, %) and the intensity range (IR, specimens) (Kaniyazov & Shakarboev, 2023; Shakarboev & Berdibaev, 2023; Abduganiev & Shakarboev, 2024).

Trematodes, cestodes, and acanthocephalans were fixed in 70% ethanol, while nematodes were preserved in Barbagallo's solution. The species composition of the trematodes, cestodes, and acanthocephalans was identified using specimens stained with carmine and prepared following standard protocols. The nematodes were stained with a 1:1 mixture of lactic acid and glycerol to determine their species composition.

The prepared specimens were examined under 20× and 40× magnifications using MBI-6, MBS-10, Biomed-6, LOMO, and Olympus microscopes. Morphometric measurements of the helminths were carried out using a calibrated optical micrometer. Both permanent and temporary mounts were prepared according to standard parasitological techniques.

Species identification of the helminths was conducted using the keys and descriptions provided by Sharpilo (1976), Anderson (2000), Khalil et al. (1994), Dawes (1964), among others. The taxonomic classification followed current nomenclature as presented in the Fauna Europaea (www.fauna-eu.org) and the Global Cestode Database (https://tapewormdb.uconn.edu).

Table 1
Species composition of the reptiles studied in the southern regions of Uzbekistan

Reptile species	Examined, specimens
*Agrionemys horsfieldi** (Gray, 1844)	13
Phrynocephalus helioscopus (Pallas, 1771)	5
Phrynocephalus reticulatus Eichwald, 1831	4
Stellio lehmanni Nikolsky, 1896	8
Phrynocephalus mystaceus (Pallas, 1776)	7
Stellio himalayanus Steindachner, 1867	5
Trapelus sanguinolentus (Pallas, 1814)	19
Pseudopus apodus (Pallas, 1775)	26
Cyrtopodion caspius (Eichwald, 1831)	8
Cyrtopodion fedtschenkoi (Strauch, 1887)	11
Teratoscincus scincus (Schlegel, 1858)	9
Eremias velox (Pallas, 1771)	48
Eremias arguta (Pallas, 1773)	24
Eremias grammica (Lichtenstein, 1823)	21
Eremias nikolskii Bedriaga, 1905	7
Eremias regeli Bedriaga, 1905	8
Eremias scripta (Strauch, 1867)	19
Ablepharus deserti Strauch, 1868	16
Psammophis lineolatus (Brandt, 1838)	10
Natrix tessellata (Laurenti, 1768)	42
Coluber ravergieri Ménétries, 1832	8
Elaphe dione (Pallas, 1773)	6
Gloydius halys (Pallas, 1776)	29
Vipera lebetina Bou-lenger, 1920	8
Echis multisquamatus Cherlin, 1981	5
Total:	366

Note: research work on the Central Asian turtle was carried out in 2010–2012.

Results

As a result of the research conducted on reptiles in various regions of Southern Uzbekistan, 37 species of helminths were recorded, belonging to 29 genera, 18 families, 6 orders, 4 classes, and 3 phyla. These included 6 species of cestodes, 5 trematodes, 1 acanthocephalan, and 25 nematodes. Of these, 10 species were found in the larval stage, while 27 occurred in the adult form.

Phylum Plathelminthes Schneider, 1873
Class Cestoda Rudolphi, 1809
Order Diphyllobothriidea Kuchta, Scholz, Brabec et Bray, 2008
Family Diphyllobothriidae Lühe, 1910
Genus *Spirometra* Müller, 1937

1. *Spirometra erinaceieuropaei* (Rud., 1819) Faust, Campbell & Kellogg, 1929, larvae

Reservoir hosts: *Natrix tesellata*, *Elaphe dione*.

Localization: subcutaneous tissue, somatic musculature, body cavity.

Prevalence of infection: Among 42 examined individuals of *Natrix tesellata*, 9 (21.4%) were infected; among 6 examined individuals of *Elaphe dione*, 1 individual (16.7%) was infected.

Intensity range: 1–3 specimens.

Discovery area: Surkhandarya Region (Termez, Kumkurgan Districts) and Kashkadarya Region (Muborak District).

Order Cyclophyllidea van Beneden in Braun, 1900
Family Anoplocephalidae Anoplocephalidae Blanchard, 1891
Genus *Oochoristica* Lühe, 1898

2. *Oochoristica tuberculata* (Rud., 1819)

Definitive hosts: *Eremias velox*, *Eremias grammica*, *Pseudopus apodus*.

Localization: small intestine.

Prevalence of infection: Among 48 examined *Eremias velox* specimens, 6 (12.5%) were infected; among 21 examined *Eremias gram-*

mica individuals, 3 (14.3%) were infected; among 26 *Pseudopus apodus* individuals, 2 (7.7%) were infected.

Intensity range: 1–4 specimens.

Discovery area: Surkhandarya Region (Jarkurgan District) and Kashkadarya Region (Yakkabog and Chiroqchi districts).

3. *Oochoristica fedtschenkoi* Bogdanov et Markov, 1955

Definitive hosts: *Psammophis lineolatus*, *Gloydius* (*Agkistrodon*) *halys*.

Localization: small intestine.

Prevalence of infection: 1 out of 10 examined *Psammophis lineolatus* individuals (10%) and 2 out of 29 *Gloydius* (*Agkistrodon*) *halys* individuals (6.9%) were infected.

Intensity range: 1–3 specimens.

Discovery area: Koson and Muborak districts of Kashkadarya Region; Sherobod and Shurchi districts of Surkhandarya Region.

Family Dipylidiidae Mola, 1929

Genus *Diplopylidium* Beddard, 1913

4. *Diplopylidium noelleri* (Skrjabin, 1924), larvae

Intermediate hosts: *Cyrtopodion fedtschenkoi*, *Cyrtopodion caspius*, *Phrynocephalus helioscopus*, *Trapelus sanguinolentus*, *Echis multisquamatus*.

Localization: liver, intestinal wall, body cavity.

Prevalence of infection: 1 out of 5 examined *Phrynocephalus helioscopus* agamas (20%), 1 out of 11 *Cyrtopodion fedtschenkoi* geckos (9.1%), 1 out of 8 *Cyrtopodion caspius* geckos (12.5%), 1 out of 19 *Trapelus sanguinolentus* agamas (5.3%), and 1 out of 5 *Echis multisquamatus* snakes (20.0%) were infected.

Intensity range: 2–5 specimens.

Discovery area: Koson, Kamashi, and Muborak districts of Kashkadarya Region; Sherobod District of Surkhandarya Region.

Genus *Joyeuxiella* Fuhrann, 1935

5. *Joyeuxiella echinorhynchoides* (Sonsino, 1889), larvae

Hosts (intermediate): *Eremias velox*, *Eremias grammica*.

Localization: liver, intestinal wall, body cavity.

Prevalence of infection: 2 out of 48 examined *Eremias velox* specimens (4.2%) and 2 out of 21 *Eremias grammica* specimens (9.5%) were infected.

Intensity range: 2–4 specimens.

Discovery area: Kasbi and Yakkabog districts of Kashkadarya Region.

Family Mesocestoidae Poiriet, 1897

Genus *Mesocestoides* Vaillant, 1863

6. *Mesocestoides lineatus* (Goeze, 1782), larvae

Hosts (Reservoir): *Pseudopus apodus*, *Eremias velox*.

Localization: liver, body cavity, pericardium, adipose tissue.

Prevalence of infection: 1 out of 26 examined *Pseudopus apodus* snakes (3.8%) and 1 out of 48 *Eremias velox* lizards (2.1%) were infected.

Discovery area: Yakkabog and Kasbi districts of Kashkadarya Region.

Class Trematoda Rudolphi, 1808

Order Plagiorchiida La Rue, 1957

Family Telorchidae Looss, 1898

Genus *Teleorchis* Lühe, 1899

7. *Telorchis assula* (Dujardin, 1845) Dollfus, 1957

Definitive hosts: *Natrix tessellata*.

Localization: intestine.

Prevalence of infection: 6 out of 42 examined *Natrix tessellata* snakes (14.3%) were infected.

Intensity range: 14–43 specimens.

Intermediate hosts: freshwater snails (*Planorbis planorbis*).

Second intermediate hosts: frogs (*Rana ridibunda*, *R. temporaria*).

Discovery area: Kamashi, Yakkabog, and Guzar districts of Kashkadarya Region; Sherobod District of Surkhandarya Region.

Family Plagiorchidae Lühe, 1901

Genus *Plagiorchis* Lühe, 1899

8. *Plagiorchis elegans* (Rud, 1802) Braun, 1902

Definitive hosts: *Eremias arguta*.

Localization: intestine.

Prevalence of infection: 2 out of 24 examined *Eremias arguta* lizards (8.3%) were infected.

Discovery area: Yakkabog and Guzar districts of Kashkadarya Region.

Genus *Macrodera* Looss, 1899

9. *Macrodera longicollis* (Abild., 1788)

Definitive hosts: *Natrix tessellata*.

Localization: lungs.

Prevalence of infection: 5 out of 42 examined *Natrix tessellata* snakes (11.9%) were infected.

Intensity range: 2–7 specimens.

Intermediate hosts: freshwater snails (*Planorbis planorbis*).

Second intermediate hosts: frogs (*Rana ridibunda*, *R. temporaria*).

Discovery area: Dehkanabad and Kamashi districts of Kashkadarya Region; Termez District of Surkhandarya Region.

Order Diplostomida Olson, Cribb, Tkach, Bray et Littlewood, 2003

Family Strigeidae Railliet, 1919

Genus *Strigea* Abildgaard, 1790

10. *Strigea strigis* (Schrank, 1788) Abildgaard, 1790, larvae

Intermediate hosts: *Natrix tessellata*, *Gloydius* (*Agkistrodon*) *halys*.

Localization: body cavity, subcutaneous tissue, adipose tissue, parietal and visceral musculature, and internal organs.

Prevalence of infection: 1 out of 42 examined *Natrix tessellata* individuals (2.4%) and 1 out of 29 *Gloydius* (*Agkistrodon*) *halys* individuals (3.4%) were infected.

Intensity range: 1–2 specimens.

Definitive hosts: herons.

Second intermediate hosts: freshwater snails.

Discovery area: Muborak and Nishon districts of Kashkadarya Region.

Family Alariidae Hall et Wigdor, 1918

Genus *Alaria* Schrank, 1788

11. *Alaria alata* (Goeze, 1782) Krause, 1914, larvae

Reservoir hosts: *Natrix tessellata*, *Elaphe dione*.

Localization: adipose tissue, body cavity, subcutaneous tissue, muscles, walls of the digestive tract, and other internal organs.

Prevalence of infection: 2 out of 42 examined *Natrix tessellata* snakes (4.8%) and 1 out of 6 *Elaphe dione* snakes (16.7%) were infected.

Intensity range: 1–3 specimens.

Discovery area: Kamashi and Guzar districts of Kashkadarya Region; Sherobod district of Surkhandarya Region.

Class Acanthocephala Rudolphi, 1880

Order Oligacanthorhynchida Petrotchenko, 1956

Family Oligacanthorhynchidae Southewell et Macfie, 1924

Genus *Macracanthorhynchus* Travassos, 1917

12. *Macracanthorhynchus catulinus* Kostylew, 1927, larvae

Intermediate hosts: *Pseudopus apodus*, *Trapelus sanguinolentus*, *Phrynocephalus mystaceus*, *Teratoscincus scincus*, *Eremias scripta*, *Gloydius* (*Agkistrodon*) *halys*, *Vipera* (*Macrovipera*) *lebetina*.

Localization: body cavity, somatic musculature, and wall of the digestive tract.

Prevalence of infection: Infection was recorded in 1 out of 26 *Pseudopus apodus* lizards (3.8%), 1 out of 19 *Trapelus sanguinolentus* agamas (5.3%), 1 out of 7 *Phrynocephalus mystaceus* agamas (14.3%), 1 out of 9 *Teratoscincus scincus* geckos (11.1%), 2 out of 19 *Eremias scripta* lizards (10.5%), 1 out of 29 *Gloydius* (*Agkistrodon*) *halys* snakes (3.4%), and 1 out of 8 *Vipera* (*Macrovipera*) *lebetina* snakes (12.5%).

Intensity range: 1–5 specimens.

Definitive hosts: carnivorous mammals.

Discovery area: Muborak, Yakkabog, and Nishon districts of Kashkadarya Region; Shurchi and Termez districts of Surkhandarya Region.

Class Nematoda Rudolphi, 1808
Order Rhabditida Oerley, 1880
Family Rhabdiasidae Railliet, 1915
Genus *Rhabdias* Stiles et Hassall, 1905
13. *Rhabdias fuscovenosa* (Railliet, 1899)
Definitive hosts: *Natrix tessellata*, *Elaphe dione*.
Localization: lungs.
Prevalence of infection: 2 out of 42 examined *Natrix tessellata* snakes (4.7%) and 1 out of 6 *Elaphe dione* snakes (16.7%) were infected.
Intensity range: 9–23 specimens.
Discovery area: Mirishkor and Muborak districts of Kashkadarya Region.

Genus *Entomelas* Travassos, 1930
14. *Entomelas dujardini* (Maupas, 1916)
Definitive hosts: *Pseudopus apodus*.
Localization: lungs.
Prevalence of infection: 1 out of 26 examined *Pseudopus apodus* individuals (3.8%) was infected.
Intensity range: 3 specimens.
Discovery area: Mirishkor District, Kashkadarya Region.

Genus *Hexadontophorus* Kreis, 1940
15. *Hexadontophorus ophisauri* Kreis, 1940
Definitive hosts: *Pseudopus apodus*.
Localization: lungs and body cavity.
Prevalence of infection: 3 out of 26 examined *Pseudopus apodus* individuals (11.5%) were infected.
Intensity range: 6–19 specimens.
Discovery area: Dehkanabad District of Kashkadarya Region and Jarkurgan District of Surkhandarya Region.

Family Strongyloididae Chitwood et Mcintosh, 1934
Genus *Strongyloides* Grassi, 1879
16. *Strongyloides mirzai* Singh, 1954
Definitive hosts: *Natrix tessellata*.
Localization: intestinal mucosa.
Prevalence of infection: 4 out of 42 examined *Natrix tessellata* snakes (9.5%) were infected.
Intensity range: 7–22 specimens.
Discovery area: Muborak and Chirakchi districts of Kashkadarya Region.

Family Ascarididae Blanchard, 1849
Genus *Polydelphis* Dujardin, 1845
17. *Polydelphis attenuate* (Mollin, 1858)
Definitive hosts: *Vipera* (*Macrovipera*) *lebetina*.
Localization: intestine.
Prevalence of infection: 1 out of 8 examined *Vipera* (*Macrovipera*) *lebetina* specimens (12.5%) was infected.
Intensity range: 3 specimens.
Discovery area: Guzar District, Kashkadarya Region.

Family Angusticaecidae Mosgovoy, 1951
Genus *Amplicaecum* Baylis, 1920
18. *Amplicaecum schikhobalovi* Mosgovoy, 1950
Definitive hosts: *Natrix tesellata*, *Coluber ravergieri*, *Vipera* (*Macrovipera*) *lebetina*.
Localization: stomach and intestine.
Prevalence of infection: A specific and widespread parasite of snakes. Infection was recorded in 9 out of 42 *Vipera* (*Macrovipera*) *lebetina* snakes (21.4%), 1 out of 8 *Coluber ravergieri* snakes (12.5%), and 2 out of 8 *Vipera* (*Macrovipera*) *lebetina* snakes (25.0%).
Intensity range: 1–27 specimens.
Discovery area: Guzar, Nishon, Yakkabog, and Kasbi districts of Kashkadarya Region, and Jarkurgan District of Surkhandarya Region.

Family Atractidae Travassos
Genus *Atractis* Dujardin, 1819
19. *Atractis dactyluris* Rudolphi, 1819
Definitive hosts: *Agrionemys* (*Testudo*) *horsfieldii*.
Localization: large intestine.
Prevalence of infection: Helminths were found in 12 out of 13 examined *Agrionemys (Testudo) horsfieldii* turtles (92.3%). The intensity of infection ranged 300 to 700 specimens.
Discovery area: Recorded in Dehkanabad and Yakkabog districts of Kashkadarya Region, as well as Sherobod and Boysun districts of Surkhandarya Region.
20. *Atractis emilii* Gallego Berenguer, 1945
Definitive hosts: *Agrionemys* (*Testudo*) *horsfieldi*.
Localization: large intestine.
Prevalence of infection: Helminths were found in 8 out of 13 examined *Agrionemys* (*Testudo*) *horsfieldii* turtles (61.5%). The intensity of infection ranged 350 to 600 specimens.
Discovery area: recorded in Dehkanabad and Yakkabog districts of Kashkadarya Region.

Family Pharyngodonidae Travassos, 1919
Genus *Pharyngodon* Diesing, 1861
21. *Pharyngodon mamillatus* (Linstow, 1897)
Definitive hosts: *Vipera* (*Macrovipera*) *lebetina*.
Localization: posterior part of the intestine.
Prevalence of infection: This species is a specific parasite of skinks. In our investigations, it was also found in *Vipera* (*Macrovipera*) *lebetina:* 1 out of 8 examined individuals (12.5%) was infected.
Intensity range: 13 specimens.
Discovery area: Kamashi District, Kashkadarya Region.
22. *Pharyngodon termezensis* (Markov et Bogdanov, 1962)
Definitive hosts: *Cyrtopodion caspius*, *Cyrtopodion fedtschenkoi*.
Localization: rectum.
Prevalence of infection: 1 out of 8 examined *Cyrtopodion caspius* geckos (12.5%) and 3 out of 11 *Cyrtopodion fedtschenkoi* geckos (27.3%) were infected.
Intensity range: 4–23 specimens.
Discovery area: Yakkabog and Kasbi districts of Kashkadarya Region.
23. *Pharyngodon elongate* Markov et Bogdanov, 1961
Definitive hosts: *Cyrtopodion fedtschenkoi*.
Localization: rectum.
Prevalence of infection: 2 out of 11 examined *Cyrtopodion fedtschenkoi* geckos (18.2%) were infected.
Intensity range: 4–23 specimens.
Discovery area: Guzar, Mirishkor districts of Kashkadarya Region.

Genus *Spauligodon* Skrjabin et al., 1960
24. *Spauligodon eremiasi* Markov et Bogdanov, 1961
Definitive hosts: *Eremias velox*, *Eremias arguta*, *Eremias scripta*, *Eremias regeli*, *Eremias nikolskii*.
Localization: rectum and cloaca.
Prevalence of infection: A widespread parasite of lizards. Among the examined hosts, 10 out of 48 *Eremias velox* lizards (20.8%), 3 out of 24 *Eremias arguta* lizards (12.5%), 1 out of 19 *Eremias scripta* lizards (5.3%), 1 out of 8 *Eremias regeli* lizards (12.5%), and 2 out of 7 *Eremias nikolskii* lizards (28.5%) were infected.
Intensity range: 3–62 specimens.
Discovery area: Yakkabog, Kamashi, Kasbi, and Dehkanabad districts of Kashkadarya Region; Sherobod and Termez districts of Surkhandarya Region.
25. *Spauligodon parasskiffi* Markov et Bogdanov, 1961
Definitive hosts: *Eremias grammica*, *Eremias scripta*.
Localization: large intestine.
Prevalence of infection: A widespread parasite of lizards. Among the examined hosts, 6 out of 21 *Eremias grammica* lizards (28.5%) and 3 out of 19 *Eremias scripta* lizards (15.7%) were infected.
Intensity range: 3–38 specimens.
Discovery area: Yakkabog, Koson, and Kamashi districts of Kashkadarya Region.

Genus *Skrjabinodon* Inglis, 1968

26. *Skrjabinodon pigmentatus* (Markov et Bogdanov, 1961)

Definitive hosts: *Eremias velox*.

Localization: large intestine.

Prevalence of infection: 3 out of 48 examined *Eremias velox* lizards were infected.

Intensity range: 3–12 specimens.

Discovery area: Sherobod District, Surkhandarya Region.

Family Oxyuridae Cobbold, 1864

Genus *Parapharyngodon* Chatterji, 1933

27. *Parapharyngodon dogieli* Markov et Bogdanov, 1965

Definitive hosts: *Stellio himalayanus*, *Trapelus sanguinolentus*.

Localization: posterior part of the intestine.

Prevalence of infection: This species is considered one of the permanent parasites of agamas. Among the examined hosts, 2 out of 5 *Stellio himalayanus* agamas (40.0%) and 5 out of 19 *Trapelus sanguinolentus* agamas (26.3%) were infected.

Discovery area: Karshi, Kamashi, and Yakkabog districts of Kashkadarya Region, and Jarkurgan District of Surkhandarya Region.

28. *Parapharyngodon brevicaudatus* (Bogdanov et Markov, 1955)

Definitive hosts: *Stellio himalayanus*, *Trapelus sanguinolentus*, *Stellio lehmanni*.

Localization: posterior part of the intestine.

Prevalence of infection: This species is regarded as one of the most widespread parasites of agamas. Infection was recorded in 3 out of 5 *Stellio himalayanus* agamas (60.0%), 11 out of 19 *Trapelus sanguinolentus* agamas (57.9%), and 2 out of 5 *Stellio lehmanni* agamas (40.0%).

Intensity range: 5–59 specimens.

Discovery area: Chirakchi, Karshi, Kamashi, Yakkabog, and Guzar districts of Kashkadarya Region, as well as Shurchi District of Surkhandarya Region.

29. *Parapharyngodon szczerbaki* Radchenko et Sharpilo, 1975

Definitive hosts: *Stellio lehmanni*, *Ablepharus deserti*.

Localization: rectum.

Prevalence of infection: Considered one of the rarely occurring parasite species in agamas. Among the examined reptiles, 1 out of 5 *Stellio lehmanni* agamas (20.0%) and 3 out of 16 *Ablepharus deserti* skinks (18.7%) were infected.

Intensity range: 4 specimens.

Discovery area: Nishon District, Kashkadarya Region.

Genus *Thelandros* Wedl, 1862

30. *Thelandros markovi* Radchenko et Sharpilo, 1975

Definitive hosts: *Stellio himalayanus*.

Localization: posterior part of the intestine.

Prevalence of infection: 1 out of 5 examined *Stellio himalayanus* agamas (20.0%) was infected.

Intensity range: 2 specimens.

Discovery area: Nishon District, Kashkadarya Region.

Family Spiruridae Oerley, 1885

Genus *Ascarops* Beneden, 1873

31. *Ascarops strongylina* (Rud., 1819), Alicata & McIntosh, 1933 larvae

Intermediate hosts: *Pseudopus apodus*, *Eremias arguta*, *Eremias velox*, *Natrix tesellata*.

Localization: stomach and intestinal walls, liver, subcutaneous tissue.

Prevalence of infection: One of the most common and widely distributed parasites of reptiles, occurring more frequently in lizards. Among the examined reptiles, 1 out of 26 *Pseudopus apodus* individuals (3.8%), 1 out of 24 *Eremias arguta* lizards (4.2%), 9 out of 48 *Eremias velox* lizards (18.7%), and 6 out of 42 *Natrix tesellata* snakes (14.3%) were infected.

Intensity range: 3–37 specimens.

Definitive hosts: mammals (domestic and wild pigs, large ruminants).

Discovery area: Dehkanabad, Mirishkor, Yakkabog, and Kamashi districts of Kashkadarya Region.

32. *Physocephalus sexalatus* Molin, 1860, (larvae)

Intermediate hosts: *Phrynocephalus mystaceus*, *Pseudopus apodus*, *Natrix tessellata*, *Stellio lehmanni*.

Localization: walls of the intestine and stomach, liver.

Prevalence of infection: Among the examined reptiles, 1 out of 7 *Phrynocephalus mystaceus* agamas (14.3%), 2 out of 26 *Pseudopus apodus* lizards (7.6%), 6 out of 42 *Natrix tessellata* snakes (14.3%), and 1 out of 8 *Stellio lehmanni* agamas (12.5%) were infected.

Intensity range: 3–42 specimens.

Definitive hosts: domestic and wild pigs, camels; intermediate hosts – coprophagous beetles.

Discovery area: Kamashi, Yakkabog, Dehkanabad, and Muborak districts of Kashkadarya Region; Sherobod and Kumkurgon districts of Surkhandarya Region.

Genus *Spirocerca* Railliet et Henry, 1911

33. *Spirocerca lupi* (Rud., 1819), larvae

Intermediate hosts: *Phrynocephalus mystaceus*, *Pseudopus apodus*, *Eremias arguta*, *E. velox*, *Gloydius* (*Agkistrodon*) *halys*, *Natrix tesellata*.

Localization: intestinal walls, stomach, body cavity, muscles, lungs, liver, subcutaneous tissue.

Prevalence of infection: Among 7 examined *Phrynocephalus mystaceus* agamas, 1 individual (14.3%) was infected; among 26 examined *Pseudopus apodus* lizards, 1 individual (3.8%) was infected; among 24 examined *Eremias arguta* lizards, 1 individual (4.2%) was infected; among 48 examined *Eremias velox* lizards, 7 individuals (14.5%) were infected; among 29 examined *Gloydius* (*Agkistrodon*) *halys* snakes, 2 individuals (6.8%) were infected; and among 42 examined *Natrix tesellata* snakes, 4 individuals (9.5%) were infected.

Intensity range: 1–27 specimens.

Definitive hosts: mammals (fox, wolf, dog).

Discovery area: Kashkadarya Region (Kamashi, Yakkabog, Mirishkor, Muborak districts) and Surkhandarya Region (Kumkurgan District).

Family Physalopteridae Railliet, 1893

Genus *Abbreviata* Travassos, 1919

34. *Abbreviata abbreviata* (Rud., 1819)

Definitive hosts: *Eremias arguta*, *Eremias velox*, *Phrynocephalus mystaceus*, *Phrynocephalus helioscopus*, *Phrynocephalus reticulatus*, *Trapelus sanguinolentus*.

Localization: stomach.

Prevalence of infection: A common parasite of lizards. Among 24 examined *Eremias arguta* lizards, 1 individual was infected; among 48 examined *Eremias velox* lizards, 3 individuals were infected; among 7 examined *Phrynocephalus mystaceus* agamas, 1 individual was infected; among 5 examined *Phrynocephalus helioscopus* agamas, 1 individual was infected; among 4 examined *Phrynocephalus reticulatus* agamas, 1 individual was infected; and among 19 examined *Trapelus sanguinolentus* agamas, 2 individuals were infected.

35. *Abbreviata kazachstanica* Markov & Paraskiv, 1956

Definitive hosts: *Teratoscincus scincus*.

Localization: stomach, occasionally the esophagus and intestines.

Prevalence of infection: Among 9 examined *Teratoscincus scincus* geckos, 1 individual (11.1%) was infected.

Intensity range: 4 specimens.

Discovery area: Kashkadarya Region (Nishon District).

Genus *Pseudabbreviata* Lichtenfels et Quigley, 1968

36. *Pseudabbreviata* sp.

Definitive hosts: *Trapelus sanguinolentus*.

Localization: stomach.

Prevalence of infection: Among 19 examined *Trapelus sanguinolentus* agamas, 1 individual (5.3%) was infected.

Intensity range: 1 specimen.

Discovery area: Kashkadarya Region (Kamashi District).

Genus *Thubunaea* Seurat, 1914

37. *Thubunaea schukurovi* Annaev, 1973

Definitive hosts: *Eremias velox*, *Eremias arguta*, *Ablepharus deserti*.

Localization: stomach.

Prevalence of infection: Among 48 examined *Eremias velox* lizards, 1 individual (2.1%) was infected; among 24 examined *Eremias arguta* lizards, 1 individual (4.2%) was infected; among 16 examined *Ablepharus deserti* skinks, 1 individual (6.25%) was infected.

Intensity range: 1-8 specimens.

Discovery area: Kashkadarya Region (Yakkabog District).

The class Trematoda was represented by 5 species, accounting for 13.5% of the total; the class Cestoda was represented by 6 species (16.2%); the class Acanthocephala was represented by 1 species (2.7%); and the class Nematoda comprised 25 species, making up 67.6% of all recorded helminths (Fig. 2).

As a result of the studies, one helminth species was found in each of the following reptile hosts: the *Phrynocephalus reticulatus*, *Cyrtopodion caspius*, *Eremias grammica*, *Eremias nikolskii*, *Eremias regeli*, *Eremias scripta*, *Psammophis lineolatus*, *Coluber ravergieri*, and *Echis multisquamatus*. Two helminth species were recorded in *Agrionemys horsfieldi*, *Phrynocephalus helioscopus*, *Teratoscincus scincus*, and *Ablepharus deserti*; three species in *Stellio himalayanus*, *Stellio lehmanni*, *Cyrtopodion fedtschenkoi,* and *Elaphe dione*; four species in *Phrynocephalus mystaceus*, *Gloydius halys*, and *Vipera lebetina*; six species in *Trapelus sanguinolentus* and *Eremias arguta*; eight species in *Pseudopus apodus*; nine species in *Eremias velox*; and eleven helminth species in *Natrix tesellata*. In total, the taxonomic structure of reptilian helminths comprised 37 species (Table 2).

The analysis of the helminth fauna in reptiles enables identification of host-specific helminth species and provides insights into the quantitative and qualitative distinctiveness of helminth communities across different reptile families, groups, and suborders.

Helminthofauna of the suborder Cryptodira (hidden-necked turtles). In the Central Asian fauna, terrestrial tortoises include two species: *Testudo graeca* (Mediterranean tortoise) and *Agrionemys horsfieldii* (Central Asian desert tortoise). These species are ecologically similar, inhabiting arid steppes, rocky and clay deserts, mountain slopes, and cultivated lands. Their diet consists exclusively of plants. *Agrionemys horsfieldii* is widely distributed across Uzbekistan.

Two species of nematodes – *Atractis dactyluris* and *Atractis emilii* – parasitize the gastrointestinal tract of the Central Asian desert tortoise. These nematodes are helminths with a direct life cycle and are specific parasites of tortoises. They are typically found in mixed infections, with a prevalence of 50–90% and an infection intensity ranging 300 to 700 specimens. Transmission occurs through ingestion of contaminated food, which facilitates the continuation of the helminth life cycle. The helminth fauna of *A. horsfieldii* is distinctly different from that of other reptile groups.

Helminth fauna of the Lacertilia suborder. In the herpetofauna of Uzbekistan, the lizard suborder comprises 38 species. A total of 245 individuals from 17 species were examined for helminths (Table 3). The overall helminth infection prevalence was 24.1%, including nematodes (17.1%), cestodes (4.5%), acanthocephalans (2.0%), and trematodes (0.4%).

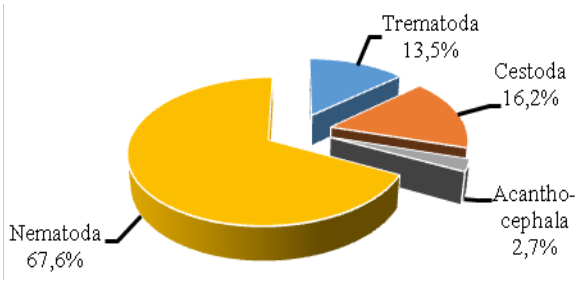

Fig. 2. Distribution of helminths of reptiles in Southern Uzbekistan by class

The prevalence of helminths across different families within the lizard suborder varied significantly, ranging 12.5% to 39.6%. In all families, nematodes ranked first in terms of infection rates, with a prevalence ranging 10.5% to 60.0%.

No consistent patterns were observed in the infection of reptiles with cestodes and acanthocephalans. The families Gekkonidae, Agamidae, and Lacertidae showed cestode infection rates ranging 6.3% to 20.0%, while acanthocephalan infections ranged 3.8% to 14.3%. The incidence of trematode infections across all the representatives of the lizard suborder was very low. Such a sharp variation in helminth infections is attributed to a number of environmental factors.

Table 2

The incidence of helminths among reptile species of Southern Uzbekistan

Name of helminth families	*Agrionemys horsfieldi*	*Phrynocephalus helioscopus*	*Phrynocephalus reticulatus*	*Phrynocephalus mystaceus*	*Stellio himalayanus*	*Stellio lehmanni*	*Trapelus sanguinolentus*	*Pseudopus apodus*	*Cyrtopodion caspius*	*Cyrtopodion fedtschenkoi*	*Teratoscincus scincus*	*Eremias velox*	*Eremias arguta*	*Eremias grammica*	*Eremias nikolskii*	*Eremias regeli*	*Eremias scripta*	*Ablepharus deserti*	*Psammophis lineolatus*	*Natrix tessellata*	*Coluber ravergieri*	*Elaphe dione*	*Gloydius halys*	*Vipera lebetina*	*Echis multisquamatus*
Telorchiidae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
Plagiorchiidae	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–
Strigeidae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–
Alariidae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–
Diphyllobothriidae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–
Anoplocephalidae	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–	1	–	–	–	1	–	–
Dipylidiidae	–	1	–	–	–	–	1	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
Mesocestoidae	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Oligacanthorhynchidae	–	–	–	1	–	–	1	1	–	–	1	–	–	–	–	–	1	–	–	–	–	–	1	1	–
Rhabdiasidae	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–
Strongyloididae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
Ascarididae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
Angusticaecidae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	1	–
Atractidae	2																								
Pharyngodonidae	–	–	–	–	–	–	–	–	1	2		2	1	1	1	1	–	–	–	–	–	–	–	1	–
Oxyuridae	–	–	–	–	3	2	2	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Spiruridae	–	–	–	2	–	1	–	3	–	–	–	2	2	–	–	–	–	–	–	3	–	–	1	–	–
Physalopteridae	–	1	1	1	–	–	2	–	–	–	1	2	2	–	–	–	–	1	–	–	–	–	–	–	–
18	1	2	1	4	3	3	6	8	1	3	2	9	6	1	1	1	1	2	1	11	1	3	4	4	1

Table 3
Examined reptiles and their infection with helminths

Species of reptiles	Examined	Total Infected		Trematodes		Cestodes		Acanthocephalans		Nematodes	
		quantity	%	quantity	%	quantity	%	quantity	%	quantity	%
Agrionemys horsfieldi	13	2	15.4	–	–	–	–	–	–	2	15.4
Phrynocephalus helioscopus	5	2	40.0	–	–	1	20.0	–	–	1	20.0
Phrynocephalus reticulatus	4	1	25.0	–	–	–	–	–	–	1	25.0
Stellio lehmanni	8	3	37.5	–	–	–	–	–	–	3	37.5
Phrynocephalus mystaceus	7	4	57.1	–	–	–	–	1	14.3	3	42.8
Stellio himalayanus	5	3	60.0	–	–	–	–	–	–	3	60.0
Trapelus sanguinolentus	19	6	31.6	–	–	1	5.3	1	5.3	4	21.1
Pseudopus apodus	26	8	30.7	–	–	2	7.7	1	3.8	5	19.2
Cyrtopodion caspius	8	2	25.0	–	–	1	12.5	–	–	1	12.5
Cyrtopodion fedtschenkoi	11	3	27.3	–	–	1	9.1	–	–	2	18.2
Teratoscincus scincus	9	2	22.2	–	–	–	–	1	11.1	1	11.1
Eremias velox	48	9	18.8	–	–	3	6.3	–	–	6	12.5
Eremias arguta	24	6	25.0	1	4.2	–	–	–	–	5	20.8
Eremias grammica	21	3	14.2	–	–	2	9.5	–	–	1	4.7
Eremias nikolskii	7	1	14.3	–	–	–	–	–	–	1	14.3
Eremias regeli	8	1	12.5	–	–	–	–	–	–	1	12.5
Eremias scripta	19	3	15.8	–	–	–	–	1	5.3	2	10.5
Ablepharus deserti	16	2	12.5							2	12.5
Psammophis lineolatus	10	1	10.0	–	–	1	10.0	–	–	–	–
Natrix tessellate	42	11	26.2	4	9.5	1	2.4	–	–	6	14.3
Coluber ravergieri	8	1	12.5	–	–	–	–	–	–	1	12.5
Elaphe dione	6	3	50.0	1	16.7	1	16.7	–	–	1	16.7
Gloydius (Agkistrodon) halys	29	4	13.7	1	3.4	1	3.4	1	3.4	1	3.4
Vipera (Macrovipera) lebetina	8	4	50.0	–	–	–	–	1	12.5	3	37.5
Echis multisquamatus	5	1	20.0	–	–	1	20.0	–	–	–	–
Total:	366	86	23.5	7	1.9	16	4.4	7	1.9	56	15.3

In reptiles of the lizard suborder, 24 helminth species were recorded, including 4 cestodes, 1 trematode, 1 acanthocephalan, and 18 nematodes. More than half of these (15 species) are typical reptile parasites. In general, the helminth fauna of lizards also includes larval stages of helminths whose adult forms parasitize birds and mammals.

The helminth composition across reptile families varied greatly in both quality and quantity (Table 4)

The most diverse helminth fauna was found in the Agamidae (19 species) and Lacertidae (true lizards) families (23 species), while other lizard families showed limited diversity. Across all families, nematodes dominated numerically (2–8 species), followed by cestodes (1–2 species), trematodes (1 species), and acanthocephalans (1 species).

Table 4
Distribution of helminths among reptile families

Names of reptile families	Number of helminths	Trematodes	Cestodes	Acanthocephals	Nematodes
Testudinidae	2	–	–	–	2
Agamidae	19	–	2	2	15
Anguidae	8	–	2	1	5
Gekkonidae	7	–	2	1	4
Lasertidae	23	1	5	1	16
Scincidae	2	–	–	–	2
Colubridae	16	5	3	–	8
Crotalidae	4	1	1	1	1
Viperidae	5	–	1	1	3

Among the lizards, *Eremias velox*, *Eremias arguta*, *Pseudopus apodus* and *Trapelus sanguinolentus* had the richest helminth fauna. *Eremias regeli*, *Eremias nikolskii,* and *Phrynocephalus reticulatus* had the smallest number of helminth species among the studied reptiles of the southern regions of Uzbekistan. The remaining lizard species were infected with 2 to 5 helminth species and exhibited a moderate level of infection.

Infection of all species of lizards with helminths with a complex life cycle occurs when feeding on invertebrates that are intermediate or additional hosts of parasites. In addition, due to their close contact with wet litter, lizards are prone to infections with nematodes with a direct life cycle.

The Serpentes suborder. In the reptilian fauna of Uzbekistan, snakes are represented by 21 species. During helminthological investigations, we examined 108 individuals belonging to 7 species. The overall helminth infection rate was 23.2%. The mean infection rates were: cestodes – 4.6%, trematodes – 5.6%, acanthocephalans – 1.8%, and nematodes – 11.1%. Among the snakes, species from the families Colubridae and Viperidae were found to be the most susceptible. The species *Gloydius (Agkistrodon) halys*, belonging to the family Crotalidae, was examined helminthologically, and four helminth species were identified parasitizing it.

The degree of helminth infection varied among different snake families. In total, 16 species of helminths were recorded in the suborder Serpentes, including 4 trematodes, 3 cestodes, 1 acanthocephalan, and 8 nematodes. Of these, 8 species were specific to snakes (*Telorchis assula*, *Macrodera longicollis*, *Oochoristica fedtschenoi*, *Rhabdias fuscovenosus*, *Strongyloides mirzai*, *Polydelphis attenuata*, *Amplicaecum schikhobalovi*, *Pharyngodon mamillatus*).

The helminth fauna of snakes also included 8 larval forms of helminths, which equals the number of species specific to snakes. These included 2 trematodes, 2 cestodes, 1 acanthocephalan, and 3 nematodes. Among the snake families studied, the highest helminth diversity was found in the family Colubridae (12 species), while each of the two remaining families hosted 4 species.

A study of the helminth species diversity in the snakes from the Kashkadarya and Surkhandarya regions showed that *Natrix tessellata* harbored the most diverse parasitic fauna. This composition is attributed to its semiaquatic lifestyle and feeding habits. Contact with aquatic environments and, to a lesser extent, the consumption of tailless amphibians, promotes the infection of *N. tessellata* by larval trematodes. Additionally, *N. tessellata* acquires mature trematodes from amphibians, which serve as additional hosts.

Thus, as a result of the study of the helminth fauna of the suborders Cryptodira (cryptodiran turtles), Lacertilia (lizards), and Serpentes (snakes), it was established that out of 366 individuals, 86 (23.5%) were infected.

Infection of the reptiles with trematodes accounted for 4.4%, cestodes – 1.9%, acanthocephalans – 1.9%, and nematodes – 15.3%. In total, 37 species of helminths were registered in the reptiles of Southern Uzbekistan, including 5 species of trematodes, 6 species of cestodes, 1 species of acanthocephalan, and 25 species of nematodes.

Of the total number of helminths registered in the reptiles, 27 (72.9%) were their obligate parasites. They are adapted to parasitism in the body of the studied cold-blooded animals and form the core of the helminth fauna of reptiles in the southern regions of Uzbekistan. Larval forms of helminths accounted for 10 species (27.02%). They

do not have a narrow host specificity for a particular reptile species. The infection of the host is mainly associated with trophic relationships. No accidental helminths were recorded among the reptile helminths.

The range of hosts (definitive, intermediate, reservoir) for different types of helminths varied widely. Thus, 7 (18.9%) species of helminths were adapted to parasitize a wide range of hosts (polyxenous, more than 4 host species); 13 (35.1%) species were adapted to 2–3 host species (oligoxenous); and 17 (39.1%) species were adapted to a single host species (monoxenous). Of the polyhostal helminth species, the broadest ranges of hosts were observed for: *Diplopylidium noelleri*, larvae (recorded in 4 species of reptiles), *Macracanthorhynchus catulinus*, larvae (7), *Spauligodon eremiasi* (4), *Ascarops strongylina*, larvae (4), *Physocephalus sexalatus*, larvae (4), *Spirocerca lupi*, larvae (6), and *Abbreviata abbreviate* (6).

It was established that of the 37 registered species of helminths, according to the nature of their life cycles, 24 (64.8%) were heteroxenic helminths, and 13 (35.1%) were monoxenic. It should be noted that heteroxenic helminths dominated in the helminth fauna of the reptiles. Of the 37 helminths, the suborder Cryptodira (cryptodiran turtles) was found to have 2 species, the suborder Lacertilia (lizards) harbored 19 species, and the suborder Serpentes (snakes) contained 12 species.

Discussion

General diversity of helminths. The present study documented 37 helminth species in reptiles of Southern Uzbekistan, representing 3 phyla, 4 classes, and 6 orders. Nematodes were the most prevalent group, comprising 67.6% of the total species recorded. This dominance contrasts with the findings from some European regions, where nematodes were not consistently the predominant group (Carbonara et al., 2023). Such regional differences are likely attributable to variations in ecological conditions and host species composition. Nevertheless, a large-scale survey conducted in the Middle Volga region in 2025 confirmed a high prevalence of nematodes in reptiles (Kirillov et al., 2025). The relatively low prevalence of trematodes and cestodes aligns with observations from other parts of the world. For example, the extensive research in Peru reported a similarly reduced occurrence of trematodes in reptiles, attributed to the limited availability of intermediate hosts, such as mollusks and amphibians (Cuellar et al., 2022). A comparable pattern was observed in our study area, where the desert-steppe ecosystems of the Kashkadarya and Surkhandarya regions limit the aquatic habitats necessary for trematodes to complete their life cycles. Acanthocephalan representatives were recorded at a very low prevalence (2.7%), which is consistent with observations from other regional studies (Kirillov et al., 2025). Nevertheless, these parasites often use reptiles as paratenic hosts and can subsequently infect mammals and birds (Choi et al., 2010). Therefore, they represent an epidemiologically important group.

Host-specific patterns. According to our results, the dice snake (*Natrix tessellata*) harbored the richest helminth fauna. This finding is likely related to the species' semiaquatic lifestyle, its position in the trophic chain, and its amphibian-based diet. Similar observations were reported in the studies conducted in Russia, where water-associated species were found to be more susceptible to trematode and cestode infections compared with other reptiles (Kirillov & Kirillova, 2021).

Reptiles as paratenic hosts. In the reptiles from Southern Uzbekistan, 72.9% of the recorded helminths were obligate parasites, well adapted to their hosts. Additionally, 27.0% were larval stages, which, although primarily associated with mammals and birds, occur in reptiles as temporary (paratenic) hosts. This indicates that reptiles function as natural paratenic hosts. This conclusion is supported by recent studies, which highlight the important role of reptiles in the transmission of zoonotic helminths (Mendoza-Roldan et al., 2020). Some species, such as *Diplopylidium noelleri*, larval *Macracanthorhynchus catulinus*, and *Spauligodon eremiasi*, are multi-host (polyxenous) parasites. This characteristic facilitates their broad distribution and persistence across diverse ecosystems. Global analyses further indicate that multi-host helminths remain stable within ecosystems and pose a high risk of infection (Kirillov et al., 2025).

Case study: the Central Asian tortoise. According to P. I. Khristianovsky et al. (2023), the Central Asian tortoise (*Agrionemys horsfieldii*) is one of four reptile species in Kazakhstan whose international trade is regulated under the CITES Convention (UN Convention on International Trade in Endangered Species of Wild Fauna and Flora). The family Testudinidae is listed in Appendix II of CITES. Between October and December 2019, Orenburg State Agrarian University temporarily held 4,448 individuals of *Testudo* (*Agrionemys*) *horsfieldii* that had been confiscated from smugglers. Under crowded conditions, 708 tortoises died, and 300 of these were dissected. Nematodes of the genus *Tachygonetria* were found in their intestines. The prevalence of infection was 100%, with an average intensity of 1,000 to 5,000 nematodes per host. Acute inflammation was observed in various parts of the intestinal tract. The pathological changes were attributed to the reptiles' stress and overcrowding, which significantly facilitated massive helminth infections. Significant differences were observed between the recent observations on the Central Asian tortoise and its associated parasites and those from Northern Iran, where intestinal helminths of *Mauremys caspica* were recorded (Youssefi et al., 2016). In the study conducted on the population of *Agrionemys horsfieldii*, intestinal helminths were found to be extremely abundant: thousands of *Tachygonetria* nematodes were detected in each animal, and the prevalence of infection reached 100%. By contrast, the studies in Northern Iran investigated the intestinal parasites of *Mauremys caspica* and recorded several species of nematodes and trematodes (Youssefi et al., 2016). The significance of that study lies in the fact that it documented, for the first time, helminth species previously unreported from this region. A comparative analysis of the two studies suggests that under natural conditions, infections are more likely to remain subclinical; however, when animals are kept in groups or transported, parasite loads tend to increase, raising the likelihood of severe disease.

Regional and international comparisons. The helminth fauna recorded in Southern Uzbekistan can be directly compared with the data from neighboring regions. In Afghanistan, Jablonski et al. (2021) reported only five nematode species in *Laudakia nuristanica* and *Paralaudakia caucasia*: *Abbreviata achari*, *Thelandros masaae*, *Thelandros taylori*, *Thelandros baylisi*, and *Parapharyngodon kasauli*. By contrast, our findings revealed 15 species of nematodes, 2 species of cestodes, and 2 species of acanthocephalans within the family Agamidae. This indicates a richer helminth fauna in agamas of Kashkadarya and Surkhandarya provinces, likely reflecting the greater trophic base and habitat diversity of this region. The work of Al-Barwari & Saeed (2007) on reptiles in Iraq also reported a predominance of nematodes; however, their findings were based mainly on the data from the families Gekkonidae, Colubridae, Testudinidae, Bataguridae, and Trionychidae. In the Lankaran natural region, Musaeva (2012) reported that *O. tuberculata* and *A. abbreviata* were the most common parasites in *Lacerta strigata lizards*, with prevalence rates ranging 6.3–22.2% and 9.5–27.7%, respectively. In our study, the infestation rates in the lizards were quite similar (7.7–14.3%; 4.2–25.0%). Our results revealed a richer spectrum of species (37 in total), indicating that the region has a high biocoenotic diversity and that anthropogenic factors (such as irrigated agriculture and the presence of livestock) provide additional opportunities for parasite life cycles to be maintained.

New records and scientific significance. This study documents, for the first time, *Skrjabinodon pigmentatus* in *Eremias velox* in Southern Uzbekistan, along with new distribution records of polyxenous larval parasites such as *Spirocerca lupi* and *Physocephalus sexalatus*. These discoveries contribute to a more comprehensive characterization of the helminth fauna of Central Asian and establish a basis for meaningful cross-border comparisons.

Overall synthesis. Taken together, the results of this study align with global evidence showing that helminth diversity in reptiles is shaped by ecological conditions, host biology, and trophic interactions. By revealing both the commonalities and unique features of the reptile-helminth system in Southern Uzbekistan, this work enhances our understanding of parasite ecology across Central Asia.

Conclusion

The overall infection of the representatives of the suborders of snakes and lizards was almost the same (24.1% and 23.2%, respectively). However, the species composition of helminths in the lizards was 1.5 times greater (24 species) than in the snakes (16 species). At the same time, obligate parasites dominated in the helminth fauna of the lizards, while larval forms of helminths predominated in the snakes. The similarity of the helminth fauna of individual reptile species from different regions of Southern Uzbekistan is due, first of all, to the species specificity of helminths, as well as the wide distribution of specific species of reptile parasites and the geographic proxymity of the studied areas.

Of the 37 helminth species recorded in the reptiles, 2 were found in the suborder Cryptodira (cryptodiran turtles), 19 in the suborder Lacertilia (lizards), and 11 in the suborder Serpentes (snakes). The number of species common to both lizards and snakes was five.

The analysis of the helminth fauna of the studied animals to a certain extent makes it possible to identify the characteristics of the species composition of helminths of individual host species and to understand the quantitative and qualitative uniqueness of the helminth fauna of certain groups of animals, families, suborders, or other taxa.

Considering the participation of representatives of reptiles in the circulation of helminths, it is recommended to take into account the degree of infection of reptiles with helminths when developing measures against helminth infections in farm and domestic animals.

In the territory of the Kashkadarya and Surkhandarya regions, 37 species of helminths belonging to 27 genera, 17 families, 7 orders, 4 classes, and 3 phyla were registered in the reptiles.

The *Agrionemys horsfieldi* turtles had 2 species of nematodes, *Atractis dactyluris* and *Atractis emilii*, which parasitize the gastrointestinal tract of the host and were found in a state of mixed infection.

In the reptiles of the lizard suborder, 24 species of helminths were recorded, including 4 species of cestodes, 1 trematode, 1 acanthocephalan, and 18 nematodes. More than half of them (15 species) are characteristic parasites of reptiles.

In total, 16 species of helminths were registered in the suborder of snakes, including 4 species of trematodes, 3 cestodes, 1 acanthocephalan and 8 nematodes. Among the mentioned helminths, 8 species of helminths turned out to be specific to snakes.

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