

A review of mites and ticks parasitizing rock lizards (Lacertidae: *Darevskia*)

Maria V. Orlova^{1✉}, Igor V. Doronin², Pavel B. Klimov³, and Nikolay V. Anisimov⁴

¹Tyumen State Medical University, Tyumen, Russia. National Research Tomsk State University, Tomsk, Russia, masha_orlova@mail.ru

²Zoological Institute of Russian Academy of Sciences, Saint Petersburg, Russia

³School of Natural Sciences, Bangor University, Bangor, Wales, United Kingdom

⁴Tyumen State University, Tyumen, Russia

Received 2 November 2021; Accepted 4 January 2022

ABSTRACT. Rock lizards of the genus *Darevskia* are interesting research models due to their asexual reproduction. Ectoparasitic mites and ticks of these lizards are poorly known, despite some of these chelicerates being vector pathogens of humans and wildlife. Here we document and curate previously known data on ectoparasitic Acari of rock lizards and, based on our extensive survey, provide an annotated list of these ectoparasitic arthropods (six tick species, one macronyssid species, and seven chigger species). We also provide new host records (*Ixodes ricinus* on *Darevskia caucasica*, *D. dryada*, *D. mixta*, and *D. szczerbaki*; *Haemaphysalis sulcata* on *D. rudis*; *Odontacarus saxicolis* on *D. brauneri*); and new geographical records (*O. saxicolis* in Russia and Georgia). *Journal of Vector Ecology* 47(1): 19-28. 2022.

Keyword Index: Rock lizards, *Darevskia*, *Haemaphysalis*, *Ixodes ricinus*, *Ophionyssus saurorum*, Trombiculidae.

INTRODUCTION

With 872 papers published since 1834–2021 (<https://lacerta.de/AS/Home.php>, accessed 2021), rock lizards of the genus *Darevskia* Arribas, 1999 are one of the most studied groups of reptiles in the Palaearctic. The genus *Darevskia* is unique in having natural parthenogenesis, a rare phenomenon in amniote vertebrates (Darevsky 1958) having implications in evolutionary biology (Borkin and Darevsky 1980). The genus includes about 33 species distributed from the Balkan Peninsula in the west to the Kopet-Dag, Turkmenistan in the east (Uetz et al. 2019), occurring at altitudes up to 3,200 m above sea level. In many areas, rock lizards are the most numerous vertebrates, but some taxa are endemic, having narrow ranges and are protected species. Rock lizards inhabit a wide variety of biotopes, such as meadows and edges of deciduous forests, tree trunks, dry, stony areas in forests, dry and moderately dry rocks and their foothills on slopes with dry-loving shrub and grassy vegetation, clay cliffs in the mountain-steppe and mountainous meadow zones, rock outcrops, individual boulders, and heaps of large stones in mountain meadows, subalpine, and alpine zones (Doronin 2015).

Here we study ectoparasitic mites associated with rock lizards preserved at the Zoological Institute of the Russian Academy of Sciences (ZISP), which holds the largest collection of these animals in terms of diversity and specimen numbers. To complete this review, we also used literature data on ectoparasites, which inevitably introduced uncertainties associated with historical host taxonomy and incomplete distribution data. For example, many authors followed the old classification placing the majority of rock lizard taxa into *Lacerta saxicola* Eversmann, 1834. In many cases, host records were not accompanied by a locality, depository, or accession

ID. Similarly, historical references did not recognize the division of *D. praticola* (Eversmann, 1834) s.l. (= *Darevskia (praticola)* complex) into the two allopatric subspecies or species: *D. praticola* and *D. pontica* (Lantz & Cyrén 1918) (Tuniyev et al. 2011).

MATERIALS AND METHODS

Host specimens were collected in Russia (Krasnodar and Stavropol Regions and Kabardino-Balkaria), Georgia, Abkhazia, Azerbaijan, and Turkey, preserved in alcohol, and deposited in ZISP. In 2021, we carefully examined 352 host individuals and found ectoparasites on 25 specimens. Ticks and chiggers were still attached to their lizard hosts, so potential museum cross contamination can be excluded (Figures 1 and 2). The taxa of rock lizards from the *Darevskia (saxicola)* complex were diagnosed using molecular genetic methods (Doronin et al. 2013). Morphological identification of ticks was done by the first author based on keys of Serdyukova (1956), Micherdzinski (1980), Kudryashova (1998), and Estrada-Peña et al. (2017). Chigger mite specimens were mounted on permanent microscopic slides in Faure-Berlese's mounting medium. Specimens were examined by MVO under a compound microscope (AxioImager A2, Zeiss, Germany). For SEM microscopy, alcohol-preserved ticks were freeze-dried and scanned using a TESCAN MIRA3 LMU (Czech Republic). Slide-mounted specimens were deposited in ZISP.

RESULTS

Three hundred fifty-two rock lizards belonging to 20 species (60% of the total species diversity) were examined: *D. armeniaca* (Méhely, 1909), *D. brauneri* (Méhely, 1909), *D. caucasica* (Méhely, 1909) *D. chlorogaster* (Boulenger, 1908),



Figure 1. Ixodid tick attached to the host.

D. daghestanica (Darevsky, 1967), *D. dahli* (Darevsky, 1957), *D. derjugini* (Nikolsky, 1898), *D. dryada* (Darevsky & Tuniyev, 1997), *D. lindholmi* (Szczerbak, 1962), *D. mixta* (Méhely, 1909), *D. parvula* (Lantz & Cyrén, 1913), *D. portschinskii* (Kessler, 1878), *D. pontica* (Lantz & Cyrén, 1918), *D. praticola* (Eversmann, 1834), *D. raddei* (Boettger, 1892), *D. rostombekowi* (Darevsky, 1957), *D. rudis* (Bedriaga, 1886), *D. saxicola* (Eversmann, 1834), *D. szczerbaki* (Lukina, 1963), and *D. valentini* (Boettger, 1892). Seventy-two ticks belonging to two species and 21 chigger mites (one species) were collected. Information on each ectoparasite species is given below.

Family Ixodidae C.L. Koch, 1844

Genus *Haemaphysalis* C.L. Koch, 1844

Distribution of the genus: cosmopolitan.

Haemaphysalis sulcata Canestrini et Fanzago, 1878 (Figure 3).

Material: 5 L ex *D. rudis*, Kvemo-Boshury settlement, Georgia, 41°52' N 43°56' E, 23 VII 1963, leg. I.S. Darevsky (collection lot number ZISP 17746).

Distribution: Spain, France, Italia, Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Albania, northern Macedonia, Bulgaria, Romania, Greece, Cyprus, Southern Russia (Crimea, Dagestan), Georgia, Azerbaijan, Armenia, Turkey, Iran, Saudi Arabia, India, Algeria, Libya, Tunisia, Morocco (Zolotarev 1949, Pomerantzev 1950, Filippova 1997, Keskin et al. 2013).

Rock lizard hosts: *D. armeniaca* (as *L. armeniaca* – Danielyan 1968), *D. daghestanica* (as *L. saxicola caucasica* – Zolotarev 1949), *D. portschinskii* (Danielyan 1968), *D. pontica* (as *L. praticola* – Lukina 1966, Markov et al. 1964), *D. praticola* (Radchenko et al. 1984), *D. raddei* (as *L. saxicola nairensis*, *L. saxicola raddei* – Danielyan 1968), *D. rudis* (new record).

Other hosts: reptiles and birds are hosts for immature ticks, while large mammals, including cattle and sheep, are



Figure 2. Three ixodid ticks attached to *Darevskia praticola*.

the major hosts for adults of *H. sulcata* (Keskin et al. 2013).

Pathogen transmission: *Babesia* sp. and *Theileria* sp. (Hoogstraal et al. 1981), *Anaplasma ovis* (Walker et al. 2003.), *A. phagocytophilum* (Aktas et al. 2012).

Haemaphysalis punctata Canestrini et Fanzago, 1878

Distribution: Sweden (Gotland, Öland), Denmark, Poland, Russia (including Crimea), Netherlands, Belgium, Great Britain, Switzerland, France (including Corsica), Spain, Portugal, Italy (including Sicilia and Sardinia), Czech Republic, Slovakia, Hungary, Slovenia, Croatia, Serbia, Bosnia and Herzegovina, Kosovo, Northern Macedonia, Ukraine, Moldova, Romania, Bulgaria, Albania, Greece, Cyprus, Turkey, Lebanon, Egypt, Algeria, Libya, Tunisia, Morocco (Raad et al. 2020).

Rock lizard hosts: *D. daghestanica* (as *L. saxicola caucasica* – Zolotarev 1949), *D. dahli* (Danielyan, 1968), *D. raddei* (as *L. saxicola nairensis* – Danielyan 1968), *D. rostombekowi* (Danielyan 1968), *D. saxicola* (Tertyshnikov 2002), *D. valentini* (Danielyan 1968).

Other hosts: small vertebrates, such as hares, hedgehogs, and birds are hosts of immature stages, while adults mainly feed on wild and domestic ungulates, particularly cattle, sheep, and goats (Estrada-Peña et al. 2017).

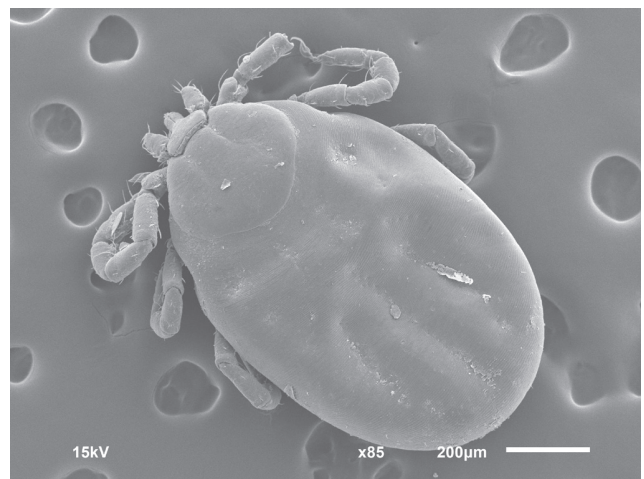


Figure 3. *Haemaphysalis sulcata* larva.

Pathogen transmission: *Babesia bigemina*, *B. major*, *B. motasi*, *Brucella*, *Rickettsia sibirica*, *R. helvetica*, *R. massiliae*, *R. nr hoogstraalii*, *R. monacensis*-like *Rickettsia*, *Anaplasma bovis*, *A. centrale*, *A. phagocytophilum*, *Coxiella burnetii*, *Theileria* spp., *Borrelia burgdorferi* s.l., *Francisella tularensis* (Estrada-Peña et al. 2017).

Haemaphysalis parva (Neumann, 1897)

Distribution: Russia (Dagestan Republic, Krasnodar and Stavropol Region), Georgia, Azerbaijan, Turkmenia, Macedonia, Romania, Turkey, Iraq, Syria, Palestine, Jordan (Schulze, 1918, Feldman-Muhsam 1951, Serdyukova 1956, Hoogstraal and Kaiser 1958, 1959, Feider et al. 1958, Kadatskaya and Shirova 1963, El-Rabie et al. 1990).

Rock lizard hosts: *D. daghestanica* (as *Haemaphysalis otophila* – Zolotarev 1949), *D. pontica* (as *H. otophila* – Lukina 1966, Markov et al. 1964), *D. praticola* (as *H. otophila* – Radchenko et al. 1984).

Other hosts: small mammals (hares, hedgehogs), birds, and lizards are hosts for immature stages; adults feed mainly on wild and domestic ungulates, particularly cattle, sheep, and goats. *H. parva* can attack humans (Estrada-Peña et al. 2017).

Pathogen transmission: *Babesia ovis* (Filippova 1997), *Coxiella burnetii* (the causative agent of Q fever) (Filippova 1997), *Francisella tularensis* (Filippova 1997), *Rickettsia hoogstraalii* (Orkun et al. 2014), *Candidatus 'Rickettsia goldwasserii'* (Keysary et al. 2011).

Haemaphysalis caucasica Olenev, 1928

Distribution: Ukraine, Russia (Dagestan Republic), Uzbekistan, Tajikistan, Kyrgyzstan (Zolotarev 1949, Serdyukova 1956, Akramova et al. 2016).

Rock lizard hosts: *Darevskia* sp. (as *L. saxicola* – Serdyukova 1956), *D. daghestanica* (as *L. saxicola caucasica* – Zolotarev 1949).

Other hosts: hares are the most common hosts of all life history stages, also occurs on bears, jackals, and foxes. Nymphs can also feed on lizards (Serdyukova 1956).

Pathogen transmission: unknown.

Genus *Ixodes* Latreille, 1795

Distribution of the genus: cosmopolitan (Filippova 1997).

Ixodes ricinus Linnaeus, 1758 (Figure 4).

Material: Russia: 4 N, 22 L ex *D. braueri*, Absheron forestry (Krasnodar Region) 44°31' N 39°37' E, 13 VII 2019, leg. N.E. Shevchenko (collection lot number ZISP 30499); N ex *D. braueri* from Otdalenniy settlement (Krasnodar Region) 44°04' N 39°42' E, 8 VII 2019, leg. N.E. Shevchenko (collection lot number ZISP 30498); 6 L ex *D. pontica*, Goryachiy Klyuch (Krasnodar Region) 44°42' N 39°22' E, 21 VII 2016, leg. N.E. Shevchenko (collection lot numbers ZISP 29691, 29692); L ex *D. pontica* from Goryachiy klyuch town (Krasnodar Region) 44°36' N 39°02' E, 3 VIII 2016, leg. N.E. Shevchenko (collection lot number ZISP 29690); N ex *D. praticola* from sanctuary "Debry" (Stavropol' Region)

44°13' N 43°15' E, 28 V 2020, leg. I.V. Doronin (collection lot number ZISP 31086); 2 L ex *D. praticola* from Cherek Gorge, Verkhnee Goluboe Lake (Kabardino-Balkaria Republic) 43°14' N 43°34' E, 11 VIII 2004, leg. K.Yu. Lotiev (collection lot number ZISP 29671); N, 4 L ex *D. praticola*, Novopavlovsk (Stavropol Region) 43°56' N 43°40' E, 12 VII 2013, leg. I.V. Doronin (collection lot numbers ZISP 27012, 27013); 2 L ex *D. szczyrbaki* from cape Idokopas (Krasnodar Region) 44°24' N 38°19' E, 9-10 VIII 2001, leg. D.A. Melnikov (collection lot number ZISP 22217/2). Georgia: N ex *D. caucasica* nr Kazbegi 42°40' N 44°37' E, 14 VI 1964, leg. I.S. Darevsky (collection lot number ZISP 17786); L ex *D. caucasica* from Lagodekhy 41°51' N 46°17' E, 25 VII 1964, leg. I.S. Darevsky (collection lot number ZISP 17819/23); 2 L ex *D. dryada* from gorges of Charnaly and Charkhichely rivers 41°33' N 41°36' E, 12-13 VII 1977, leg. V.I. Vedmederya, Yu.V. Sviridenko (collection lot numbers ZISP 19907/1, 2); 6 L ex *D. dryada* from gorge of Charnaly river 41°33' N 41°36' E, 5 IX 1976, leg. I.S. Darevsky (collection lot numbers ZISP 18809, 18810); L ex *D. mixta* from gorge of Banis-Khevy river 41°52' N 43°25' E, 23 VII 1959, leg. I.S. Darevsky (collection lot number ZISP 17426); N, L ex *D. rudis* from Keda settlement 41°36' N 41°57' E, 12 VII 1058, leg. V. Petrov (collection lot number ZISP 17523). Azerbaijan: 4 L ex *D. chlorogaster* from Bilyasar settlement 38°38' N 48°42' E, 1 VI 1974, leg. I.S. Darevsky (collection lot number ZISP 18510/2).

Distribution: Southern Scandinavia to the Mediterranean Sea, European Russia, Northern Africa (Serdyukova 1956, Pérez and Rodhain 1977).

Rock lizard hosts: *D. braueri* (as *L. saxicola* – Lukina 1966, Kidov et al. 2014, our data), *D. caucasica* (new record), *D. chlorogaster* (Drozdov 1964, this article), *D. daghestanica* (as *L. saxicola caucasica* – Zolotarev 1949), *D. derjugini* (Timoshina et al. 2013), *D. dryada* (new record), *D. mixta* (new record), *D. pontica* (Kidov et al. 2014), *D. praticola* (as *L. praticola* – Radchenko et al. 1984, Kidov 2018, our data), *D. rudis* (as *L. rudis* – Keskin et al. 2012, this article), *D. saxicola* (Tertyshnikov 2002, Kidov et al. 2019), *D. szczyrbaki* (new record).

Other hosts: larvae and nymphs feed on insectivores

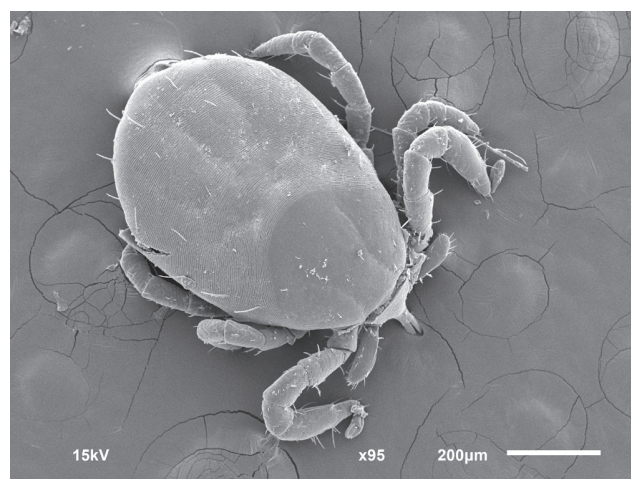


Figure 4. *Ixodes ricinus* larva.

(hedgehogs, moles, shrews), rodents (squirrels, dormice, black rats, gray rats, house mice), birds (*Accipiter nisus*, *Lyrurus tetricus*, *Tetrao urogallus*, *Tetrastes bonasia*, *Capella gallinago*), rarely reptiles (*Testudo graeca*, *L. strigata*, *Natrix natrix*, *Vipera ursinii* and others); adults feed on larger mammals, such as foxes, lynxes, horses, wild boars, roe deer, red deer, sika deer, domestic sheep, domestic goats, European mouflons. All three active stages feed on hedgehogs and hares. *I. ricinus* can attack humans (Estrada-Peña et al. 2017).

Pathogen transmission: *Borrelia burgdorferi* s.l. (Lyme borreliosis), *Anaplasma phagocytophilum* (human granulocytic anaplasmosis), *Francisella tularensis* (tularemia), *Rickettsia helvetica* and *Rickettsia monacensis* (spotted fever rickettsiosis), *Babesia divergens* and *Babesia microti* (babesiosis), *Neoehrlichia mikurensis* (neoehrlichiosis), tick-borne encephalitis virus (encephalitis), Louping ill virus (encephalitis), and Tribec virus (encephalitis) (Estrada-Peña et al. 2017).

Ixodes redikorzevi Olenov, 1927

Distribution: Southeast Europe, Anterior and Central Asia (Filippova 1997).

Rock lizard hosts: *D. chlorogaster* (as *L. chlorogaster* – Gadzhiev et al. 1982).

Other hosts: larvae, nymphs and females feed on many rodents (*Cricetulus migratorius*, *Microtus* spp., *Apodemus* spp., *Meriones* spp., *Sciurus* spp., *Citellus pygmaeus*, *Marmota bobak*, *Spalax* spp.), insectivores (hedgehogs, shrews) and other mammals (*Lepus europaeus*, *Mustela* spp., *Vormela peregusna*, *Martes martes*, *Meles meles*, *Vulpes vulpes*), birds (*Alectoris kakelik*, *Columba livia*, *Galerida cristata*, *Emberiza* spp., *Oenanthe* spp., *Frithacus rubecula*, *Anthus* spp., *Mergus serrator*, *Phylloscopus* spp., *Pica pica*), rarely reptiles (*Lacerta agilis*, *Pseudopus apodus*) (Filippova 1997).

Pathogen transmission: *Francisella tularensis* (Tiflova 1974), *Coxiella burnetii* (Pchelkina et al. 1968).

Gamasina Kramer, 1881

Family Macronyssidae Oudemans, 1936

Genus *Ophionyssus* Mégnin, 1883

Distribution of the genus: semi-cosmopolitan (Eurasia, Africa, North America) (Micherdzinski 1980).

Ophionyssus saurarum (Oudemans, 1901)

Distribution: Europe, Russia (Leningrad Province, Moscow Province, Tver Province, Saratov Province, Volgograd Province, Stavropol Region), Kazakhstan, Armenia, Azerbaijan, Korea, Sudan, South Africa (Micherdzinski 1980, Gwiazdowicz and Filip 2009, Mašán et al. 2009, Beron 2014). Rock lizard hosts. *D. brauneri* (as *L. saxicola* – Lukina 1966), *D. armeniaca* (as *L. armeniaca* – Danielyan 1968), *D. pontica* (as *L. praticola* – Lukina 1966, Markov et al. 1964), *D. raddei* (as *L. saxicola nairensis* – Danielyan 1968), *D. valentini* (as *L. saxicola valentini* – Danielyan 1968), *D. saxicola* (Beron 2014).

Other hosts: reptiles of the families Lacertidae and Scincidae (Micherdzinski 1980).

Pathogen transmission: *Schellackia* sp. (Micherdzinski 1980), *Karyolysus* sp. (Alvarez Calvo 1978).

Superorder Acariformes Zakhvatkin, 1952 Family Trombiculidae Ewing, 1929

Genus *Ericotrombidium* Vercammen-Grandjean, 1966

Distribution of the genus: semi-cosmopolitan (Eurasia, Africa, North America) (Kudryashova 1998).

Ericotrombidium caucasicum Schluger, 1967

Distribution: Russia (Stavropol Region) (as *Leptotrombidium caucasicum* – Kudryashova 1998, Tertyshnikov 2002), Ukraine (Kudryashova 1998).

Rock lizard hosts: *D. saxicola* (Tertyshnikov 2002).

Other hosts: *L. agilis*, *Eremias arguta* (Kudryashova 1998).

Pathogen transmission: unknown.

Genus *Odontacarus* Ewing, 1929

Distribution of the genus: tropical, arid and mountainous regions of Old and New World (Kudryashova 1998).

Odontacarus hushchai Kudryashova, 1994

Distribution: Russia (Krasnodar Region), Georgia (Kudryashova, 1994).

Rock lizard hosts: *D. brauneri* (as *L. saxicola* – Kudryashova, 1994), *D. derjugini* (as *L. saxicola* – Kudryashova, 1994).

Other hosts: unknown.

Pathogen transmission: unknown.

Odontacarus saxicolis Schluger, Hushcha et Kudryashova, 1965

Material: Georgia (Abkhazia): 5 L ex *D. brauneri*, Pitsunda-Myussera state natural reserve 43°10' N 40°25'E, 17-19 VII 2010, leg. I.V. Doronin, M.A. Doronina (collection lot number ZISP 25965). Russia: 16 L ex *D. brauneri* Tuapse (Krasnodar Region) 44°05' N 39°06' E, 18 VIII 2009, leg. I.V. Doronin, M.A. Doronina (collection lot number ZISP 25737).

Distribution: Russia (Krasnodar Region) (new record), Georgia (Abkhazia) (new record), Azerbaijan (Kudryashova 1998), Armenia (Kudryashova 1998).

Rock lizard hosts: *D. raddei* (Kudryashova 1998), *D. brauneri* (new record).

Other hosts: unknown.

Pathogen transmission: unknown.

Genus *Lacertacarus* Schluger & Vasilieva, 1977

Distribution of the genus: Caucasus (Russia – Krasnodar Region, Georgia, Armenia, Azerbaijan).

Lacertacarus latus Schluger & Vasilieva, 1977

Distribution: Russia (Krasnodar Region), Georgia (Kudryashova 1998).

Rock lizard hosts: *D. derjugini* (Kudryashova 1998).

Other hosts: unknown.

Pathogen transmission: unknown.

Table 1. Host and distribution of mites and ticks parasitizing rock lizards (continued on following pages).

Species	Crimea	Caucasus					Anatolia (Turkey)	No locality	
		Stavropol Region	Krasnodar Region	Dagestan Republic	Georgia	Armenia			Azerbaijan
<i>Darevskia armenitaca</i> (Méhely, 1909)									
<i>Darevskia braueri</i> (Méhely, 1909)			<i>Ixodes ricinus</i> ^{4, 5, 20} <i>Haemaphysalis</i> sp. ⁵ <i>Ophiomyssus saurarum</i> ⁵ <i>Odontacarus hushchaj</i> ¹⁴		* <i>Odontacarus saxicolis</i> ⁸	<i>Haemaphysalis sulcata</i> ¹ <i>Ophiomyssus saurarum</i> ¹ <i>Ixodidae</i> ¹⁵			
<i>Darevskia caucasica</i> (Méhely, 1909)									
<i>Darevskia chlorogaster</i> (Boulenger, 1908)								<i>Ixodes ricinus</i> ^{23, 8} <i>I. redikorzevi</i> ¹³ <i>Ophiomyssus</i> sp. (as <i>Sauromyssus</i> sp.) ¹³	
<i>Darevskia daghestanica</i> (Darevsky, 1967)				<i>Ixodes ricinus</i> ¹⁹ <i>Haemaphysalis parva</i> ¹⁹ <i>H. punctata</i> ¹⁹ <i>H. sulcata</i> ¹⁹ <i>H. caucasica</i> ¹⁹					
<i>Darevskia dahli</i> (Darevsky, 1957)							<i>Haemaphysalis punctata</i> ¹ <i>Ixodidae</i> ¹⁵		
<i>Darevskia derjugini</i> (Nikolsky, 1898)			<i>Ixodes ricinus</i> ²¹			<i>Lacertacarus similis</i> ¹⁴ <i>Lacertacarus latus</i> ¹⁴ <i>Odontacarus hushchaj</i> ¹⁴			

¹Danielyan 1968, ²Tertyshnikov 1992, ³Tertyshnikov 2002, ⁴Tertyshnikov, Gorovaya 1984, ⁵Lukina 1966, ⁶Vshivkov, Shluger 1960, ⁷Markov et al. 1964, ⁸Stanyukovich, Iogansen 2004, ⁹Radchenko et al. 1984, ¹⁰Arutyunyan et al. 2013, ¹¹Yilmaz et al. 2018, ¹²Kidov et al. 2019, ¹³Gadzhiev et al. 1982, ¹⁴Kudryashova 1998, ¹⁵Vartanyan et al. 2011, ¹⁶Keskin et al. 2012, ¹⁷Serdyukova 1956, ¹⁸Beron 2016, ¹⁹Zolotarev 1949, ²⁰Kidov et al. 2014, ²¹Timoshina et al. 2013, ²²Kidov 2018, ²³Drozov 1964, ²⁴This article, ²⁵Recorded for Abkhazia.

Table 1. Host and distribution of mites and ticks parasitizing rock lizards (continued on following pages).

Species	Crimea	Caucasus						Anatolia (Turkey)	No locality
		Stavropol Region	Krasnodar Region	Dagestan Republic	Georgia	Armenia	Azerbaijan		
<i>Darevskia dryada</i> (Darevsky et Tuniyev, 1997)					<i>Ixodes ricinus</i> [#]				
<i>Darevskia lindholmi</i> (Szczerbak, 1962)	<i>Neotrombicula (Polymasticula) tragardhiana</i> ⁶								
<i>Darevskia mixta</i> (Méhely, 1909)					<i>Ixodes ricinus</i> [#]				
<i>Darevskia parvula</i> (Lantz et Cyrén, 1913)					<i>Odontacarus hushchaj</i> ¹⁴				
<i>Darevskia portschinskii</i> (Kessler, 1878)						<i>Haemaphysalis sulcata</i> ¹ Ixodidae ¹⁵			
<i>Darevskia pontica</i> (Lantz et Cyrén, 1918)					<i>Ixodes ricinus</i> ^{5, 7, 12, 20#} <i>Haemaphysalis parva</i> ^{5, 7} <i>H. sulcata</i> ^{5, 7} <i>Ophionyssus saurarum</i> ^{5, 7}				
<i>Darevskia praticola</i> (Eversmann, 1834)	<i>Ixodes ricinus</i> ^{9, #} <i>Haemaphysalis parva</i> (as <i>H. otophila</i>) ⁹ <i>Haemaphysalis sulcata</i> ⁹						<i>Ixodes ricinus</i> ²²		
<i>Darevskia (praticola)</i>	<i>Ixodes ricinus</i> ^{2, 3, 4} <i>Haemaphysalis parva</i> ^{3, 2, 4} <i>Ericotrombidium caucasicum</i> ³ <i>Ophionyssus saurarum</i> ²								

Table 1. Host and distribution of mites and ticks parasitizing rock lizards (continued).

Species	Crimea	Caucasus						Anatolia (Turkey)	No locality
		Stavropol Region	Krasnodar Region	Dagestan Republic	Georgia	Armenia	Azerbaijan		
<i>Darevskia raddai</i> (Boettger, 1892)					<i>Lacertacarus similis</i> ¹⁴	<i>Haemaphysalis sulcata</i> ¹ <i>Haemaphysalis punctata</i> ¹ <i>Odontacarus saxicolis</i> ¹⁴ <i>Ophiomyssus saurorum</i> ¹ <i>Ixodidae</i> ¹⁵	<i>Odontacarus saxicolis</i> ¹⁴ <i>Lacertacarus callosus</i> ¹⁴		
<i>Darevskia rostombekowi</i> (Darevsky, 1957)						<i>Haemaphysalis punctata</i> ¹ <i>Ixodidae</i> ¹⁵			
<i>Darevskia rudis</i> (Bedriaga, 1886)					<i>Ixodes ricinus</i> ⁸ <i>Haemaphysalis sulcata</i> ⁸ <i>Lacertacarus similis</i> ¹⁴		<i>Ixodes ricinus</i> ¹⁶		
<i>Darevskia saxicola</i> (Eversmann, 1834)		<i>Ixodes ricinus</i> ³ <i>Haemaphysalis punctata</i> ³ <i>Ericobombidium caucasicum</i> ³	<i>Ixodes ricinus</i> ¹²					<i>Ophiomyssus saurorum</i> ¹⁸	
<i>Darevskia szczyrbaki</i> (Lukina, 1963)			<i>Ixodes ricinus</i> ⁸						
<i>Darevskia valentini</i> (Boettger, 1892)						<i>Haemaphysalis punctata</i> ¹ <i>Ophiomyssus saurorum</i> ¹	<i>Hyalomma aegyptium</i> ¹¹		
<i>Darevskia</i> sp. (without species mention)						<i>Ophiomyssus saurorum</i> ¹⁰		<i>Ophiomyssus saurorum</i> ⁸ <i>Neotrombicula (Polymasticula) fragardhana</i> ¹⁴ <i>Haemaphysalis caucasica</i> ¹⁷	

Lacertacarus similis Schluger & Vasilieva, 1977

Distribution: Azerbaijan, Georgia (Kudryashova 1998).

Rock lizard hosts: *D. raddei* (Kudryashova 1998), *D. caucasica* ? (as *L. saxicola* – Kudryashova 1998).

Other hosts: unknown.

Pathogen transmission: unknown.

Lacertacarus callosus (Schluger, 1966)

Distribution: Armenia, Azerbaijan.

Rock lizard hosts: *D. raddei* (as *L. saxicola* – Kudryashova 1998), *D. raddei* (Kudryashova 1998).

Other hosts: *Erinaceus europaeus* (Kudryashova 1998).

Pathogen transmission: unknown.

Genus *Neotrombicula* Hirst, 1925

Distribution of the genus: cosmopolitan.

Subgenus *Polymasticula* Vercammen-Grandjean & Kolebinova, 1985

Neotrombicula (Polymasticula) tragardhiana (Feider, 1953)

Distribution: Russia (Crimea), Azerbaijan, Kyrgyzstan, Tadjikistan, Romania, Turkey (Kudryashova 1998).

Rock lizard hosts: *Darevskia* sp. (as *L. saxicolis* – Kudryashova 1998).

Other hosts: insectivores (*Crocidura russula*), rodents (*Apodemus sylvaticus*, *Microtus majori*, *M. socialis*, *M. arvalis*, *Alticola roylei*), reptiles (*L. agilis*, *L. strigata*, *Podarcis tauricus*) (Kudryashova 1998).

Pathogen transmission: unknown.

DISCUSSION

We identified fourteen acarine ectoparasite species associated with rock lizards of the genus *Darevskia*: six ticks, one gamasid, and seven chiggers. Of these, ixodid ticks and gamasid mites are known as vectors of pathogens of wild animals and humans. Rock lizards usually serve as hosts of immature ticks, while adult stages of ticks attack large animals, including humans. As a result, rock lizards, where they are abundant, can probably sustain large tick populations. Overall, studies of host-parasite associations, distribution, and patterns of parasite abundance and prevalence can contribute to our understanding of host-parasite-pathogen systems as well as host-parasite co-evolution and co-speciation.

Acknowledgments

All authors made equal contributions to the study. The authors are grateful to Alexey A. Gubin (University of Tyumen, Tyumen, Russia) for assistance with images, and Marina A. Doronina (Zoological Institute of Russian Academy of Sciences, Saint Petersburg, Russia), Konstantin Yu. Lotiev (Sochi National Park, Sochi, Russia), Daniel A. Melnikov (Zoological Institute of Russian Academy of Sciences, Saint Petersburg, Russia), and Nikolay E. Shevchenko (Center for Forest Ecology and Productivity of the Russian Academy of Sciences, Moscow, Russia) for help in research. This study was supported by the Russian Science Foundation (grant number

22-24-00079) (for Igor V. Doronin).

REFERENCES CITED

- Akramova, F.D., S.Kh. Umrkulova, D.A. Azimov, and V.I. Golovanov. 2016. Ixodid ticks in northeastern Uzbekistan: fauna, distribution patterns and ecology. *Russian J. Parasitol.* 37: 291-295.
- Aktas, M., K. Altay, S. Ozubek, and N. Dumanli. 2012. A survey of ixodid ticks feeding on cattle and prevalence of tick-borne pathogens in the Black Sea region of Turkey. *Vet. Parasitol.* 187: 567-571.
- Alvarez Calvo, J.A. 1978. Ciclo biologico de Karyolysus ootocromosomi (Sporozoa, Apicomplexa: Haemogregarinidae) en el reptil *Lacerta hispanica* Steindachner 1870 y en el acaro *Ophionyssus saurorum* Oud. 1901. *Revist. Parasitol.* 34: 27-34.
- Arutyunyan, T.K., R.K. Petrosyan, F.D. Danielyan, and M.S. Arakelyan. 2013. Influence of environmental factors on infestation of rocky lizards. *Biol. J. Armenia* 3: 130-135. (in Russian).
- Beron, P. 2014. *Acarorum Catalogus III: Opilioacarida, Holothyrida, Mesostigmata*. Pensoft & National Museum of Natural History, Sofia, 286 pp.
- Borkin, L.J. and I.S. Darevsky. 1980. Reticulate (hybridogenous) speciation in vertebrates. *J. Gen. Biol.* 16: 485-507. (in Russian).
- Danielyan, F.D. Ecological-faunistic study of bisexual and parthenogenetic species of rock lizards in Armenia. Ph.D. dissertation, Yerevan. 140 pp. (in Russian).
- Darevsky, I.S. 1958. Natural parthenogenesis in certain subspecies of rock lizard, *Lacerta saxicola*, from Armenia. *Doklady Akademii Nauk SSSR.* 122: 730-732. (in Russian).
- Doronin, I.V. 2015. Systematics, phylogeny and distribution of Rock lizards supraspecific complexes *Darevskia (praticola)*, *Darevskia (caucasica)* and *Darevskia (saxicola)*. Ph.D. dissertation, Saint-Petersburg. 371 pp. (in Russian).
- Doronin, I.V., B.S. Tuniyev, and O.V. Kukushkin. 2013. Differentiation and taxonomy of the rock lizards *Darevskia (saxicola)* (Sauria: Lacertidae) according to morphological and molecular analyses. *Proc. Zool. Instit. RAS.* 317: 54-84. (in Russian).
- Drozdov, N.N. 1964. Materials on biology of the greenbellied lizards. In: *Problems of Herpetology*. Leningrad, Publishing House of Leningrad University, pp. 21-22. (In Russian).
- El-Rabie, Y., Z.S. Amr, and K.E. Hyland. 1990. Observations on the ixodid ticks associated with domestic ungulate animals in Jordan. *Zool. Middle East* 4: 85-92.
- Estrada-Peña, A., A.D. Mihalca, and T.N. Petney. (eds). 2017. *Ticks of Europe and North Africa: A Guide to Species Identification*. Springer, 404 pp.
- Feider, Z., C.U. Rauchbach, and I. Mironescu. 1958. Die Zecken der Rumänischen Volksrepublik. *Československá Parasitol.* 2: 71-87.
- Feldman-Muhsam, B. 1951. A note on East Mediterranean

- species of the genus *Haemaphysalis*. Bull. Res. Council Israel 1: 96-107.
- Filippova, N.A. 1997. *Fauna of Russia and Neighboring Countries. Arachnoidea. Vol. IV, issue 5. Ixodid ticks of subfamily Amblyomminae*. Russian Academy of Sciences, Zoological Institute, New Series № 145, Nauka Publishing House, Saint-Petersburg, 436 pp. (in Russian).
- Gadzhev, A.T., Z.A. Mustafaeva, and S.G. Dzhaferova. 1982. Ectoparasites of lizards (Sauria, Reptilia) of Azerbaijan. Parasitological research in Azerbaijan. Baku, Elm. pp. 59-60. (in Russian).
- Gwiazdowicz, D.J. and K.P. Filip. 2009. *Ophionyssus saurorum* (Acari, Mesostigmata) infecting *Lacerta agilis* (Reptilia, Lacertidae). Wiad. Parazytol. 55: 61-62.
- Hoogstraal, H. and M. Kaiser. 1958. Observations on the ticks (Ixodoidea) of Iraq with special reference to the genus *Hyalomma*. J. Iraqi Med. Profess. 1: 58-84.
- Hoogstraal, H. and M. Kaiser. 1959. Ticks (Ixodoidea) from Arabia with special reference to the Yemen. Fieldiana (Zoology). 39: 291-322.
- Hoogstraal, H., H.Y. Wassef, and W. Bunniker. 1981. Ticks (Acarina) of Saudi Arabia. Fam. Argasidae, Ixodidae. Fauna Saudi Arabia. 3: 25-110.
- Kadatskaya, K.P. and L.F. Shirova. 1963. Ixodid ticks and fleas in the tularemia focus of the Nakhichevan ASSR. Doklady Akademii nauk Azerbajjanskoy SSR. 19: 79-83. (in Russian).
- Keskin, A., E. Simsek, and A. Bursali. 2012. Two new host data for *Ixodes ricinus* (Acari: Ixodidae); *Lacerta media* and *Lacerta rudis* (Diapsida: Lacertidae). 21. Proc. Natl. Biol. Congr., Izmir, Turkey. p. 1021.
- Keskin, A., A. Bursali, Y. Kumlutas, C. Ilgaz, and S. Tekin. 2013. Parasitism of immature stages of *Haemaphysalis sulcata* (Acari: Ixodidae) on some reptiles in Turkey. J. Parasitol. 99: 752-755.
- Keysary, A., M.E. Eremeeva, M. Leitner, A.B. Din, M.E. Wikswo, K.Y. Mumcuoglu, M. Inbar, A.D. Wallach, U. Shanas, R. King, and T. Waner. 2011. Spotted fever group rickettsiae in ticks collected from wild animals in Israel. Am. J. Trop. Med. Hyg. 85: 919-923.
- Kidov, A.A., E.G. Kovrina, A.L. Timoshina, K.A. Matushkina, A.A., Baksheyeva, K.A. Afrin, and S.A. Blinova. 2014. Parasitism of the common tick *Ixodes ricinus* on syntopic lizards of azalea oak-woods of Northwestern Caucasus. Bull. Buryat State Univ. 4: 44-48. (in Russian).
- Kidov, A.A. 2018. Parasite-host relationships of the ixodid tick *Ixodes ricinus* (Linnaeus, 1758) and Hyrcanian meadow lizard *Darevskia praticola hyrcanica* (Tuniyev, Doronin, Kidov & Tuniyev, 2011) in Talysh Mountains (Southeastern Azerbaijan). Russian J. Parasitol. 12: 27-34. (in Russian).
- Kidov, A.A., A.A. Ivanov, and E.A. Nemyko. 2019. Assessment of host-parasite relationship *Ixodes ricinus* and rock lizards (Lacertidae: *Darevskia pontica* and *D. saxicola*) in Psebai reserve (Krasnodar Region). University proceedings. Volga region. 3: 67-76. (in Russian).
- Kudryashova, N.I. 1994. Revision of the subgenus *Odontacarus* (Acariformes, Trombiculidae) of the Palearctic. Acarina 2: 3-46.
- Kudryashova, N.I. 1998. *Chiggers (Acariformes, Trombiculidae) of Eastern Palaearctic*. KMK Scientific Press LTD, Moscow, 342 pp. (in Russian).
- Lukina, G.P. 1966. Reptiles of the Western Ciscaucasia. Ph.D. dissertation, Rostov-on-Don, 218 pp. (in Russian).
- Markov, G.S., G.P. Lukina, L.N. Markova, and A.A. Mozzgina. 1964. Contribution to parasite fauna of Northern Caucasus. Scientific notes of the Volgograd State Pedagogical Institute named after A.S. Serafimovich. 46: 99-101. (in Russian).
- Mašán, P., R. Václav, and P. Prokop. 2009. First record of the lizard-parasitizing mite, *Ophionyssus saurorum* (Acari: Macronyssidae) in Slovakia. Entomof. Carpathica 21: 10.
- Micherdzinski, W. 1980. *Eine Taxonomische Analyse der Familie Macronyssidae, Oudemans, 1936. I: Subfamilie Ornithonyssinae, Lange, 1958 (Acarina: Mesostigmata)*. Polska Akad. Nauk, Warszawa, 254 pp.
- Orkun, O., Z. Karaer, A. Cakmak, and S. Nalbantoglu. 2014. Spotted fever group rickettsiae in ticks in Turkey. Ticks and Tick-Borne Dis. 5: 213-218.
- Pchelkina, A.A., A.A. Berdyev, Z.M. Zhmaeva, and I.N. Kostyrko. 1968. About combined foci of Q-rickettsiosis and tick-borne typhus of North Asia on the territory of Turkmenistan. Healthcare Turkmenistan. 12: 18-22. (in Russian).
- Pérez, C. and F. Rodhain, 1977. Biologie d'*Ixodes ricinus* L. 1758. 1. Écologie, cycle évolutif. Bull. Soc. Pathol. Exot. 70: 187-201.
- Pomerantzev, B.I. 1950. *Ixodid ticks* (Ixodidae). In: *Fauna of the USSR*, New series 41: Arachnoidea, vol. 4, issue 2. Leningrad, Nauk, p. 224. (in Russian).
- Raad, M., D. Azar, and A.M. Perotti. 2020. First report of the ticks *Haemaphysalis punctata* Canestrini & Fanzago, 1878, *Haemaphysalis parva* (Neumann, 1897) and *Dermacentor marginatus* (Sulzer, 1776) (Acari, Amblyommidae) from humans in Lebanon. Acta Parasitol. 65: 541-545.
- Radchenko, N.M., M.F. Tertysnikov, and V.P. Sharpilo. 1984. About the parasite fauna of amphibians and reptiles of the Stavropol Region. Fauna and ecology of amphibians and reptiles. Kubanskiy State University, Krasnodar, pp. 84-86. (in Russian).
- Schulze, P. 1918. Beitrag zur Zeckenfauna Mazedoniens. Sitzsber. Ges. Naturf. Freunde Berlin. 1-2: 61-66.
- Serdyukova, G.V. 1956. *Ixodid Ticks of USSR Fauna. Keys to the Fauna of the USSR*. Academy of Sciences of the USSR; 64. Publishing House Acad. of Sciences of the USSR, Moscow, Leningrad, 122 pp.
- Shluger, E.G., and F.N. Vshivkov. 1960. Trombiculidae ticks of Crimea. Problems of parasitology (Proceedings of the 3rd scientific conference of parasitologists of the Ukrainian SSR). pp. 296-298.
- Stanyukovich, M.K. and L.K. Iohansen. 2004. Ticks (Acari, Parasitiformes, Macronyssidae) are parasites of reptiles. Actual problems of gerpetology and toxinology. Collection of scientific papers. 7: 122-128. (in Russian).
- Tertysnikov, M.F. 1992. Reptiles of the Ciscaucasia: fauna, taxonomy, ecology, significance, protection, genesis.

- Sc.D. dissertation, Stavropol, 383 pp. (in Russian).
- Tertyshnikov, M.F. 2002. *Reptiles of the Central Ciscaucasia*. Stavropol'servisshkola, Stavropol, 240 pp.
- Tertyshnikov, M.F. and V.I. Gorovaya. 1984. *Reptiles of the Stavropol Region. Part 1 (Turtles, Lizards)*. Fauna Stavropol Region. 3: 48-91.
- Tiflova, L.A. 1974. Features of the ecology of the tick *Ixodes redikorzevi redikorzevi* Ol., 1927 in the Ciscaucasia and its role in the epizootology of tularemia. Ph.D. thesis. Leningrad, 21 pp.
- Timoshina, A.L., K.A. Matushkina, A.A. Kidov, A.V. Kovalev, and E.G. Kovrina. 2013. Lacertid lizards (Reptilia: Sauria: Lacertidae) as hosts of common tick, *Ixodes ricinus* (Linnaeus, 1758) (Acari: Parasitiformes: Ixodidae) in Northwestern Caucasus. Bull. Tambov State Univ. 18: 3082-3084. (in Russian).
- Tuniyev, S.B., I.V. Doronin, A.A. Kidov, and B.S. Tuniyev. 2011. Systematic and geographical variability of the meadow lizard, *Darevskia praticola* (Reptilia: Sauria) in the Caucasus. Russian J. Herpetol. 18: 295-316.
- Uetz, P., S. Cherikh, G. Shea, I. Ineich, P.D. Campbell, I.V. Doronin, J. Rosado, A. Wynn, K. A. Tighe, R. McDiarmid, J.L. Lee, G. Köhler, R. Ellis, P. Doughty, C.J. Raxworthy, L. Scheinberg, A. Resetar, M. Sabaj, G. Schneider, M. Franzen, F. Glaw, W. Böhme, S. Schweiger, R. Gemel, P. Couper, A. Amey, E. Dondorp, G. Ofer, S. Meiri, and V. Wallach. 2019. A global catalog of primary reptile type specimens. Zootaxa 4695: 438-450.
- Vartanyan, L.K., N.O. Sargsyan, and T.K. Arutyunyan. 2011. To the study of parasitofauna of reptiles of Armenia. Proceedings of the International Scientific Conference "Biological Diversity and Problems of Conservation of the Fauna of the Caucasus" (September 26-29, 2011, Yerevan, Armenia). Asogik, Yerevan, pp. 96-98. (in Russian).
- Walker, A.R., A. Bouattour, J.L. Camicas, A. Estrada-Pena, I.G. Horak, A. Latif, R.G. Pegram, and P.M. Preston. 2003. *Ticks of Domestic Animals in Africa: A Guide to Identification of species*. Bioscience Reports, Edinburgh. U.K. 221 pp.
- Yilmaz, A.B., O. Orunc Kilinc, O. Adizel, E. Bulum, and N. Yuksek. 2018. Ticks collected from reptile species on Small Nemrut Mountain (Tatvan/Bitlis/Turkey). Medyc. Weteryn. 74: 445-448.
- Zolotarev, N.A. 1949. The importance of reptiles and amphibians in the development of ticks in Dagestan. Proceedings of the sector of zoology and animal husbandry of the Dagestan scientific research base of the Academy of Sciences of the USSR. 2: 67-78. (in Russian).