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RESEARCH ARTICLE

An updated checklist of ticks and mites (Acari) reported on reptiles of Türkiye: New records and new host-parasite associations

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ASBTRACT: Reptiles are terrestrial tetrapods with a cosmopolitan distribution worldwide, with a diversity of more than 10,000 species. Due to this diversity, there are many interactions with both animals and humans within the ecosystem. Naturally, the reptiles affect the life cycle of many ectoparasites that transmit pathogenic or nonpathogenic agents to humans and animals. In this study, it was aimed to reveal the ectoparasitic fauna of reptiles commonly found in Sakarya, Samsun, and Artvin provinces between 2021 and 2023. The study examined 1021 individuals in 26 different host species (tortoise, gecko, lizards and snakes). At the end of the examination, the tick specimens were identified as *Ixodes ricinus* (Linnaeus) and *Hyalomma aegyptium* (Linneaus); mite specimens were identified as *Hemilaelaps farrieri* (Tibbetts), *Ophionyssus natricis* (Gervais), *Op. saurarum* (Oudemans), *Odontacarus efferus* Kudryashova, *Od. hushchai* Kudryashova, *Od. naumovi* Kudryashova and Rybin, *Od. saxicolis* Schluger, Huschcha and Kudryashova, *Lacertacarus callosus* (Schluger), *L. similis* Schluger and Vasilieva, and *Geckobia turkestana* Hirst. Among these ectoparasites, *H. farrieri*, *Od. efferus*, *Od. hushchai*, *Od. naumovi* and *Od. saxicolis* were detected on reptiles for the first time in Türkiye. In addition, ectoparasitic species detected in the studies conducted to date on reptiles in Türkiye are also listed in the appendix section.

Keywords: Faunistic records, *Hemilaelaps*, *Odontacarus*, reptile ectoparasites
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INTRODUCTION

Reptiles are terrestrial tetrapods with a cosmopolitan distribution, with over 10,000 species classified under four orders in current taxonomy: Crocodilia (crocodiles), Rhynchocephalia (lizard-like reptiles), Squamata (lizards and snakes) and Testudines (turtles) (Budak and Göçmen, 2014; Uetz et al., 2019). Depending on their rich species diversity and cosmopolitan distribution, they interact with other living creatures and humans within the ecosystem, and as a result of the predator-prey relationship in the food web, they contribute to the life cycle of protozoan and metazoan (trematode, cestode, nematode, and arthropod) parasites as vector and intermediate or final hosts (Greiner, 2003; Bower et al., 2018; Mendoza-Roldan et al., 2020). Because of this, reptiles are frequently studied in veterinary parasitology, and the zoonotic potentials of the ectoparasitic agents they carry have been investigated (Kampen et al., 2004; Mendoza-Roldan et al., 2019).

Research on the herpetofauna of Türkiye started at the beginning of the 19th century and has continued increasingly until today; it has been published by the Turkish and foreign researchers as checklists for herptiles (reptiles and amphibians) in various periods (Bodenheimer, 1944; Başoğlu and Baran, 1977; Demirsoy, 1997; Sindaco et al., 2000; Baran et al., 2021). Due to some characteristics of Türkiye's territory, the reptile fauna has shown great diversity: (1) Its territory is located in significant parts of three different biodiversity hotspots, namely the Mediterranean, Iran-Turan and the Caucasus, which have a significant impact on species diversity; (2) Its territory is located within two important geographical regions such as Europe-Siberia and the Eastern Mediterranean, which are important in terms of herpetology; (3) It also has mountain ranges and therefore isolated geographical regions due to altitude (Mittermeier et al., 2004; Şekercioğlu et al., 2011; Ficetola et al., 2018; Kurnaz, 2020; Yaşar et al., 2021). Considering the current checklist of Türkiye's reptiles and the studies published on new species in recent years, it can be seen that Türkiye's reptile fauna consists of over 140 species (Kurnaz, 2020, Yaşar et al., 2021; Arribas et al., 2022; Kurnaz et al., 2022).

It can be seen that studies on reptile ectoparasites in Türkiye started in the 1950s (Kurtpınar, 1954; Hoogstraal, 1959). In the following years, various studies have been carried out by many researchers, but in these studies, the presence of ectoparasites infesting the reptile fauna of Türkiye has not been sufficiently revealed. Up to now, nine tick species from 22 host species in seven families (Appendix I: Table 4) and 16 mite species from 37 host species in seven families (Appendix I: Table 5) were reported in faunistic ectoparasite studies on reptiles in Türkiye.

MATERIALS AND METHODS

This study was conducted in three different provinces, respectively Sakarya, Samsun, and Artvin, located on the coastline of the Black Sea region of Türkiye, during the months when reptiles were active between 2021 and 2023. Hosts were captured using the active search method. Each captured host was restrained, carefully examined for ectoparasites where it was found, and then released in the same area. The reptiles caught in the relevant study areas using the active search method were first subjected to a general external examination, and species identifications were made by taking into account the distribution maps and morphological characters and using the relevant literature (Budak and Göçmen, 2014; Baran et al., 2021; Yaşar et al., 2021). Afterwards, ectoparasite screening was performed for ticks and trombiculid mites; they were examined under a stereo microscope for mesostigmatic mites that cannot be seen with the naked eye. While tick specimens were collected with blunt-tipped forceps, mite specimens were collected using a steel syringe needle (17G). The collected ectoparasite specimens were stored in Eppendorf tubes containing 70% ethanol until morphological identification was made. Finally, Eppendorf tubes were labelled according to the host from which they were collected, the region and habitat where the host was caught, the date, the ectoparasite group and the number of rows of the specimen examined. Photographs of the reptiles subjected to ectoparasitic examination and the habitats in which they were captured were taken with a Nikon Coolpix P610 digital compact camera (Appendix II: Figures 1-5). Representative numbers of mite and tick specimens were first exposed for 48 hours with lactophenol for clearing before mounting. Then, all specimens were mounted on glass slides in the Hoyer's medium. Afterwards, the prepared slides were dried at room temperature for two weeks and adhered to with clear nail polish.

Finally, tick and mite specimens were carefully identified under a light (Nikon Eclipse 80i, Tokyo, Japan) and stereo microscope (Nikon SMZ1500, Tokyo, Japan) using relevant literature sources (Fain, 1962; Evans, 1966; Kudryashova, 1998; Apanaskevich, 2003; Stekolnikov and Daniel, 2012; Stekolnikov et al., 2014; Estrada-Peña et al., 2018). Afterwards, the identified species were photographed with the camera integrated into the microscope (Mshot Mdx4-t, Guangzhou, China). Additionally, Scanning Electron Microscopy was used to image some mesostigmatic and prostigmatic mites. As in the relevant literature (Nation, 1983; McAllister et al., 2021), the specimens were prepared, and the imaging process was carried out in the Electron Microscope Laboratory of Ondokuz Mayıs University Karadeniz Advanced Technology Research and Application Center (Samsun, Türkiye). Original photographs of the hosts examined and ectoparasites identified in the study are included in the appendix section (Appendix II and Appendix III).

RESULTS

During the study, 1021 reptile individuals, including 26 reptile species, were examined for ectoparasites, and 3006 tick and 2726 mite specimens were collected from these hosts. Of the 1021 reptile hosts examined, 580 (56.80%) were infested with one or more ectoparasite species. Of the nine different reptile host species examined in the study, *Anguis colchica* (Nordmann) (n: 58), *Ablepharus kitaibelii* (Bibron and Bory St-Vincent) (n: 14), *Hemidactylus turcicus* (Linnaeus) (n: 2), *Coronella austriaca* Laurenti (n: 6), *Natrix natrix* (Linnaeus) (n: 22), *Vipera kaznakovi* Nikolsky (n: 4), *V. ammodytes* (Linnaeus) (n: 3), *Emys orbicularis* (Linnaeus) (n: 12), and *Trachemys scripta* (Thunberg) (n: 5) no infestation was detected in a total of 128 (12.53%) individuals. Among the infested hosts, the rate of infestation with tick species alone was 54.21% (n: 315), while the rate of infestation with mite species was 53.70% (n: 312). In addition, the rate of reptiles infested with both tick and mite species was determined to be 13.45% (n: 78).

Infestation rates among lizard hosts (Anguidae, Lacertidae, and Scincidae) vary depending on the region. Infestation rates of lizards examined in Artvin, Sakarya and Samsun provinces were determined as 70.37% (n: 247), 44.37% (n: 134) and 35.59% (n: 21), respectively. Ectoparasite infestations were not detected on the slow worm (*A. colchica*) and on the snake-eyed skink (*A. kitaibelii*) (0%). The highest infestation rate was determined as 96.33% on the spiny-tailed lizard (*D. obscura*) in Artvin, 93.75% on the Bithynican spiny-tailed lizard (*D. bithynica*) in Sakarya, and 52.63% on the Bithynican spiny-tailed lizard (*D. bithynica*) in Samsun. The infestation rate in all lizard species (n: 712) examined during the study was 56.46%.

Two species of gecko were subjected to ectoparasitic examination during the study, and the infestation was detected only on the Kotschy's gecko (*M.* cf. *kotschyi*). Twenty-eight different individual Kotschy's gecko were examined from three other locations in Artvin, and the infestation was detected only in the specimens (n: 20) examined in the Cehennem Deresi Canyon located Ardanuç (71.42%) (Appendix II: Figure 3; Appendix III: Figure 11). No infestation was detected in eight individuals examined in two different locations within the borders of Borçka. In addition, no infestation was detected in the Mediterranean house gecko (*H. turcicus*) specimens examined in Samsun (0%).

Only Mediterranean spur-thighed tortoise (*Testudo graeca*) infestation was detected on the Tortoises/Turtles species examined (Appendix II: Figure 6; Appendix III: Figures 29-30). The infestation rate for the Mediterranean spur-thighed tortoise (*T. graeca*) was determined as 95.45% in Samsun and 9.52% in Sakarya. No infestation was detected in the other two turtle species examined (*Emys orbicularis* and *Trachemys scripta*). Infestation rates of snake species examined in Artvin, Sakarya and Samsun were determined as 25.92%, 4.16% and 0%, respectively. The snake species most frequently examined during the study were the grass snake (*Natrix natrix*) (n: 22), the dice snake (*N. tesselata*) (n: 22) and the Dahl's whip snake (*Platyceps najadum*) (n: 12). Their infestation rates were 0%, 13.63% and 66.66%, respectively. No infestation was detected in the smooth snake (*Coronella austriaca*), Caucasian Viper (*V. kaznakovi*), the nose-horned Viper (*V. ammodytes*) and the grass snake (*N. natrix*). During the study, 87 individuals belonging to nine different snake species were examined, and the infestation rate was 17.24%. As a result of the ectoparasitic examinations, a total of 12 ectoparasite species were identified, including two tick species from the Ixodidae family [*Ixodes ricinus* (Linnaeus) and *Hyalomma aegyptium* (Linnaeus)], three species of mesostigmatic mites [*Hemilaelaps farrieri* (Tibbetts), *Ophionyssus natricis* (Gervais), and *Op. saurarum* (Oudemans)], and seven species of prostigmatic mites [*Odontacarus efferus* (Kudryashova), *Od. hushchai* Kudryashova, *Od. naumovi* Kudryashova and Rybin, *Od. saxicolis* Schluger, Huschcha and Kudryashova, *Lacertacarus callosus* (Schluger), *L. similis* (Schluger and Vasilieva), and *Geckobia turkestana* Hirst].

DISCUSSION

Revealing reptile ectoparasite relationships is essential for its harmful effects on the host and for its harmful effects on the reptile hosts and public health. Because ticks and mites that attach to reptiles also act as vectors for many bacterial, viral, protozoan and helminthic agents (Burridge, 2001; Frances, 2005; Bower et al., 2018; Divers and Stahl, 2019; Mendoza-Roldan et al., 2019). Studies conducted worldwide for many years have shown that many mites (families Entonyssidae, Heterozerconidae, Ixodorhynchidae, Laelapidae, Macronyssidae, Omentolaelapidae, Paramegistidae, Cloacaridae, Harpirhynchidae, Pterygosomatidae, and Trombiculidae) and tick species (families Ixodidae and Argasidae) caused infestation on reptiles (Hoogstraal and Kohls, 1966; Barker and Murrell, 2004; Venzal and Estrada-Peña, 2006; Fajfer, 2012; De Alcantara et al., 2018).

In the family of Ixodorhynchidae Ewing, researchers have reported many species on almost all continents. However, it is one of the parasitic mite groups that has not been studied sufficiently in terms of both its biology and taxonomy (Fajfer, 2012; Alfonso-Toledo and Paredes-León, 2021). Taxonomic characteristics of ixodorhynchid species are mainly based on the monograph of Fain (1962). These mites, which have high host specificity, do not have zoonotic potential. So far, all species (31-43 species from six genera) described are associated with snakes (Squamata: Serpentes) (Voss, 1961; Fain, 1962; Voss and Strandtmann, 1962; Lizaso, 1983; Dowling, 2009; Beaulieu et al., 2011). When we examine the geographical regions of the reports of ixodorhynchid species, we see that they are mainly from America and Africa, especially from colubrid snakes. In the study titled "A survey of ixodorhynchid mites on snakes", published by Voss (1961), with reference to Feider and Solomon (1959), it was reported that *Hemilaelaps piger* (syn. *Ophidilaelaps ponticus*) on the grass snake (*Natrix natrix*) from Türkiye (Appendix I: Table 5). With this study, *Hemilaelaps farrieri* was detected on *Dolichophis caspius* (Colubridae) for the first time in Türkiye (Appendix III: Figures 19-24).

The Macronyssidae family includes the most common and well-known species of mites that cause infestation in reptiles. In particular, *Ophionyssus natricis* has zoonotic importance and a cosmopolitan distribution, making it one of the most studied mite species in reptiles. Although 17 species have been described in this genus, only *Ophionyssus natricis* has zoonotic potential. This species, which particularly infests snakes, also rarely infests lizards. They can also be transmitted from infested reptiles to humans and cause allergic reactions (Yunker, 1956; Schultz, 1975; Beck, 1996; Wozniak et al., 2000; Amanatfard et al., 2014). To date, no human infestation cases due to *Op. natricis* has been reported in Türkiye. In addition, *Ophionyssus saurarum*, which causes infestation on lizards within this genus, was detected in many reptiles in a large-scale study conducted in Türkiye published by Jabbarpour (2016) (Appendix I: Table 5). Unlike the *Ophionyssus* species, within the Macronyssidae family, *Draconyssus* and *Endophionyssus* species also settle in the respiratory tract of reptiles (Yunker and Radovsky, 1966; Radovsky, 2010). However, there are not enough studies on these species. In the host-parasite associations detected in this study, the red-belied lizard (*Darevskia adjarica*), the Derjugin's lizard (*D. derjugini*), the common wall lizard (*Podarcis muralis*), and the Balkan wall lizard (*P. tauricus*), are new host records for *Ophionyssus saurarum* (Appendix III: Figures 7-10).

The Pterygosomatidae family consists of mite species with extremely high host specificity, with a cosmopolitan distribution of over 180, most of which cause reptile infestation (Hirst, 1926; Walter et al., 2009; Fajfer, 2012, 2015, 2023; Bertrand et al., 2013). Pterygosomatid mites, also called scale mites, spend most of their life cycle on the host and are firmly fixed to the skin with their chelicerae. Except for some genera (*Geckobiella* Hirst, *Hirstiella* Berlese and *Pimeliaphilus* Trägardh), their host specificity is quite high. For example, *Pterygosoma* species infest iguanas, while *Geckobia* species infest geckos (Bertrand, 2002; Bertrand et al., 2012; Paredes-Leon et al., 2012). Although there have been many reports of pterygosomatid infestation on reptile hosts worldwide, the number of studies conducted in Türkiye is limited. In these studies, *Geckobia tarantula*, *G. turkestana,* and *Geckobia* sp. were reported on reptiles (Appendix I: Table 5).

Trombiculids are mites with extremely poor species specificity, but the host specificity may be observed at a certain level, such as commonly, *Whartonia* species infest bats and *Lacertacarus* species infest lizards. They are distributed on all continents except Antarctica, and mites in this parasitic group can infest mammals, birds, and reptiles (Shatrov and Kudryashova, 2008). This group of mites has seven developmental stages: egg, prelarvae (deutovum), larva, three nymphs (protonymph, deutonymph, tritonymph) and adult (Zajkowska et al., 2018). The active nymphal and adult stages of these mites, which are parasitic only in their larval stages, feed on soft-bodied arthropods (Collembola, Diptera, Hemiptera, and Lepidoptera) as well as soil-dwelling nematodes (Chaisiri, 2016). These mites also have zoonotic potential, and over 50 cases of Trombiculosis on humans have been reported all over the world to date. Species of the genera *Apolonia*, *Blankaartia*, *Blanciella*, *Euschorngastia*, *Eutrombicula*, *Gahrliepia*, *Herpetacarus*, *Kepkatrombicula*, *Leptotrombidium*, *Neotrombicula*, *Odontacarus*, and *Schoengastia* have been reported in these human cases (Rjpka and Stekolnikov, 2006; Burns, 2010; Santibáñez et al., 2015; Porras-Villamil and Javier-Olivera, 2021; Silva-de la Fuente et al., 2021; Stekolnikov and Mumcuoğlu, 2021). In addition to their parasitic effects, they are being investigated vector potentials for many agents that are pathogenic for humans and animals, such as diseases Bartonellosis, Borreliosis, Ehrlichiosis, Francisellosis, Leptospirosis, Rickettsiosis, Q fever and Hantavirus (Kampen et al., 2004; Santibáñez et al., 2015; Faccini et al., 2017; Mendoza-Roldan et al., 2021; Moniuszko et al., 2022). However, except *Orientia tsutsugamushi* (Rickettsiales: Rickettsiaceae) among these pathogen groups, no agent is confirmed to be transmitted through the bites of trombiculid mites (Santibáñez et al., 2015). Studies conducted on reptiles around the world have detected infestation of many species, such as *Ancoracarus* (Takahashi et al., 2012), *Arabapolonia* (Stekolnikov et al., 2012), *Babiangia* (Southcott, 1954), *Ericotrombidium* (Orlova et al., 2023), *Eutrombicula* (Stekolnikov and González-Acuña, 2010; Corn et al., 2014), *Hypotrombidium* (Stekolnikov, 2018), *Iguanacarus* (Vercammen-Grandjean, 1965) *Lacertacarus* (Stekolnikov et al., 2014; Kaluz, 2019; Orlova et al., 2023), *Matacarus* (Stekolnikov, 2018), *Microtrombicula* (Mockett, 2017), *Neotrombicula* (Mockett, 2017), *Odontacarus* (Mockett, 2017), *Ornithogastia* (Stekolnikov, 2018), *Pentidionis* (Stekolnikov, 2018; Er-Rguibi et al., 2023), *Schoengastia* (Orlova et al., 2023; Stekolnikov, 2021), *Schoutedenichia* (Taufflieb, 1958), *Siseca* (Takahashi and Misumi, 2011), *Vatacarus* (Nadchatram, 2006), and *Xinjiangsha* (Er-Rguibi et al., 2023). Studies conducted in Türkiye show that notifications about reptiles are at the desired level. In these studies (Kepka, 1962; Kalúz, 2011; Jabbarpour, 2016), *Matacarus demrei*, *Matacarus* sp., *Lacertacarus callosus*, *L. similis*, *L. turcicus*, *Neotrombicula autumnalis*, *Neotrombicula* sp. species were reported (Appendix I: Table 5). As a result of this study, *Odontacarus efferus* (Appendix III: Figure 15), *Od. hushchai* (Appendix III: Figure 16), *Od. naumovi* (Appendix III: Figure 17) and *Od. saxicolis* (Appendix III: Figure 18) infestations were reported from Türkiye for the first time (Appendix III: Figures 25-26). In addition to these data, in Türkiye, the red-belied lizard (*Darevskia adjarica*), the Bithynican spiny-tailed lizard (*D. bithynica*), the Clark's Lizard (*D. clarkorum*), the Derjugin's lizard (*D. derjugini*), the spiny-tailed lizard (*D. obscura*) and the common wall lizard (*Podarcis muralis*) are new host records for *Lacertacarus callosus* (Appendix III: Figure 13); *Darevskia adjarica*, *D. bithynica,* and *D. derjugini* for mite *Lacertacarus similis* are new host records (Appendix III: Figures 12 and 14).

Studies on arthropods that infest reptiles seem to focus mainly on ticks (Cumming, 1998; De Alcantara et al., 2018; Orlova et al., 2023). To date, more than one hundred ixodid ticks (*Amblyomma* spp., *Aponomma* spp., *Dermacentor* spp., *Haemaphysalis* spp., *Hyalomma* spp., and *Ixodes* spp.) and argasid (*Argas* spp. and *Ornithodoros* spp.) have been identified in ectoparasitic studies conducted on reptiles around the world (Hoogstraal et al., 1973; Pietzsch et al., 2006). In the previous studies conducted in Türkiye, *Hyalomma aegyptium*, *H. marginatum*, *Hyalomma* sp., *Heamaphysalis concinna*, *H. sulcata*, *H. parva*, *Haemaphysalis* sp., *Ixodes ricinus*, *Ixodes* sp., *Rhipicephalus annulatus* (as *R. calcaratus* in the study), *R. kohlsi*, and *R. turanicus* has been reported from the reptiles of Türkiye (Appendix I: Table 4). In this study, new host-parasite associations were revealed for *Ixodes ricinus* and *Hyalomma aegyptium* hard ticks for the fauna of ticks of Türkiye (Appendix III: Figures 27-31). The European glass lizard (*Pseudopus apodus*), the red-belied lizard (*Darevskia adjarica*), the Bithynican spiny-tailed lizard (*D. bithynica*), the Clark's Lizard (*D. clarkorum*), the Derjugin's lizard (*D. derjugini*), and the common wall lizard (*Podarcis muralis*) are new host records for *Ixodes ricinus* in Türkiye. In addition, the Balkan wall lizard (*Podarcis tauricus*) is a new host record for *Hyalomma aegyptium*, also known as tortoise tick, in Türkiye.

CONCLUSIONS

As a result of this study, five new records and various new host-parasite associations were detected. It aimed to contribute to studies on revealing the ectoparasitic fauna of reptiles in Türkiye. If evaluated in total with this study conducted, the ectoparasitic burden of Türkiye's reptile fauna consists of nine ticks and 21 mite species. It is clear that this number is well below the desired level. Türkiye territories have a rich reptile diversity, although only approximately 1/3 of the reptiles have been investigated for ectoparasitic aspects.

Authors' contributions

Gökhan Eren: Conception/design of study, methodology (equal), data acquisition, data analysis/interpretation, identification, preservation (equal), drafting manuscript, final approval and accountability (equal). **Mustafa Açıcı:** Methodology (equal), collection of specimens, preservation (equal), final approval and accountability (equal).

This work is derived from the first author's PhD dissertation.

Statement of ethics approval

This study was approved for field research by the General Directorate of Nature Conservation and National Parks of the Ministry of Agriculture and Forestry, based on the permissions dated 9/9/2020 and numbered 49933177-663.08-E.88314, and by the Local Ethics Committee for Animal Experiments of Ondokuz Mayıs University, with the decision number 2020/60 dated 26/11/2020.

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Conflict of interest

The authors declare that there is no conflict of interest.

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APPENDIX I: Lists of ectoparasites detected on the reptiles from Türkiye

Table 1. Infestation numbers on the reptile hosts according to the provinces where specimens were collected.

Province	Host	Number of examined animals (n)	Number of infested animals (n)	Number of tick infested animals (n)	Number of mite infested animals (n)	Number of co-infested animals (n)
Artvin	*Anguis colchica*	14	0	0	0	0
	Darevskia adjarica	141	96	6	96	6
	Darevskia clarkorum	28	16	9	7	7
	Darevskia derjugini	59	30	6	24	6
	Darevskia obscura	109	105	24	81	19
	Mediodactylus cf. *kotschyi*	28	14	0	14	0
	Coronella austriaca	5	0	0	0	0
	Dolichophis caspius	3	1	0	1	0
	Natrix natrix	7	0	0	0	0
	Natrix tesselata	13	3	0	3	0
	Platyceps najadum	12	8	0	8	0
	Telescopus fallax	1	1	0	1	0
	Zamenis longissimus	6	1	0	1	0
	Vipera kaznakovi	4	0	0	0	0
	Vipera ammodytes	3	0	0	0	0
Artvin Total		**433**	**275**	**45**	**236**	**38**
Sakarya	*Anguis colchica*	36	0	0	0	0
	Darevskia bithynica	16	15	3	13	2
	Lacerta viridis	131	79	79	29	24
	Podarcis muralis	84	38	34	14	14
	Podarcis tauricus	21	2	1	2	0
	Ablepharus kitaibelii	14	0	0	0	0
	Coronella austriaca	1	0	0	0	0
	Dolichophis caspius	4	0	0	0	0
	Natrix natrix	12	0	0	0	0
	Natrix tesselata	4	0	0	0	0
	Zamenis longissimus	3	1	0	1	0
	Emys orbicularis	7	0	0	0	0
	Trachemys scripta	3	0	0	0	0
	Testudo graeca	21	2	2	0	0
Sakarya Total		**357**	**137**	**119**	**59**	**40**
Samsun	*Anguis colchica*	8	0	0	0	0
	Pseudopus apodus	12	3	3	0	0
	Darevskia bithynica	19	10	0	10	0
	Lacerta media	20	8	1	7	0
	Hemidactylus turcicus	2	0	0	0	0
	Dolichophis caspius	1	0	0	0	0
	Natrix natrix	3	0	0	0	0
	Natrix tesselata	5	0	0	0	0
	Emys orbicularis	5	0	0	0	0
	Trachemys scripta	2	0	0	0	0
	Testudo graeca	154	147	147	0	0
Samsun Total		**231**	**168**	**151**	**17**	**0**
Total		**1021**	**580**	**315**	**312**	**78**

Table 2. Infestation rates according to the reptile host species.

Province	Host	Number of examined host (n)	Number of infested host (n)	Infestation rate (%)
Artvin	*Anguis colchica*	14	0	%0
	Darevskia adjarica	141	96	%68.08
	Darevskia clarkorum	28	16	%57.14
	Darevskia derjugini	59	30	%50.84
	Darevskia obscura	109	105	%96.33
	Mediodactylus cf. *kotschyi*	28	14	%71.42
	Coronella austriaca	5	0	%0
	Dolichophis caspius	3	1	%33.33
	Natrix natrix	7	0	%0
	Natrix tesselata	13	3	%23.07
	Platyceps najadum	12	8	%66.66
	Telescopus fallax	1	1	%100
	Zamenis longissimus	6	1	%16,66
	Vipera kaznakovi	4	0	%0
	Vipera ammodytes	3	0	%0
Artvin Total		**433**	**275**	**63.51**
Sakarya	*Anguis colchica*	36	0	%0
	Darevskia bithynica	16	15	%52.63
	Lacerta viridis	131	79	%60.30
	Podarcis muralis	84	38	%45.23
	Podarcis tauricus	21	2	%9.52
	Ablepharus kitaibelii	14	0	%0
	Coronella austriaca	1	0	%0
	Dolichophis caspius	4	0	%0
	Natrix natrix	12	0	%0
	Natrix tesselata	4	0	%0
	Zamenis longissimus	3	1	%33.33
	Emys orbicularis	7	0	%0
	Trachemys scripta	3	0	%0
	Testudo graeca	21	2	%9.52
Sakarya Total		**357**	**137**	**%38.37**
Samsun	*Anguis colchica*	8	0	%0
	Pseudopus apodus	12	3	%25
	Darevskia bithynica	19	10	%52.63
	Lacerta media	20	8	%40
	Hemidactylus turcicus	2	0	%0
	Dolichophis caspius	1	0	%0
	Natrix natrix	3	0	%0
	Natrix tesselata	5	0	%0
	Emys orbicularis	5	0	%0
	Trachemys scripta	2	0	%0
	Testudo graeca	154	147	%95.45
Samsun Total		**231**	**168**	**%72.72**
Total		**1021**	**580**	**%56.80**

Table 3. Hosts and detected ectoparasite (mite and tick) species.

Provinces	Order	Family	Species	Hosts
Artvin	Ixodida	Ixodidae	*Ixodes ricinus*	Sauria: *Darevskia* (*D.*) *adjarica*, *D. clarkorum*, *D. derjugini*, and *D. obscura*
	Mesostigmata	Ixodorhynchidae	*Hemilaelaps farrieri*	Squamata: *Dolichophis caspius*
		Macronyssidae	*Ophionyssus natricis*	Squamata: *Natrix tessellata*
			Ophionyssus saurarum	Sauria: *Darevskia adjarica*, *D. derjugini*, and *D. obscura*
	Prostigmata	Pterygosomatidae	*Geckobia turkestana*	Sauria: *Mediodactylus* cf. *kotschyi*
		Trombiculidae	*Lacertacarus callosus*	Sauria: *Darevskia adjarica*, *D. clarkorum*, *D. derjugini*, and *D. obscura*
			Lacertacarus similis	Sauria: *Darevskia adjarica*, *D. clarkorum*, *D. derjugini*, and *D. obscura*
			Odontacarus efferus	Sauria: *D. adjarica*, *D. derjugini, and D. obscura* Squamata: *Coronella austriaca*, *Platyceps najadum*, *Telescopus fallax,* and *Zamenis longissimus*
			Odontacarus hushchai	Sauria: *Darevskia adjarica, D. clarkorum*, and *D. obscura*
			Odontacarus naumovi	Sauria: *Darevskia adjarica, D. clarkorum*, and *D. obscura*
			Odontacarus saxicolis	Sauria: *Darevskia adjarica, D. clarkorum*, and *D. obscura*
Sakarya	Ixodida	Ixodidae	*Hyalomma aegyptium*	Sauria: *Podarcis tauricus* Testudinata: *Testudo graeca*
			Ixodes ricinus	Sauria: *Darevskia bithynica*, *Podarcis muralis*, and *Lacerta viridis*
	Mesostigmata	Macronyssidae	*Ophionyssus saurarum*	Sauria: *Darevskia bithynica*, *Lacerta viridis*, *Podarcis muralis*, and *P. tauricus*

	Prostigmata	Trombiculidae	*Lacertacarus callosus*	Sauria: *Podarcis muralis*
			Lacertacarus similis	Sauria: *Darevskia bithynica and Podarcis muralis*
			Odontacarus efferus	Sauria: *Darevskia bithynica*, *Podarcis muralis, and P. tauricus* Squamata: *Zamenis longissimus*
Samsun	**Ixodida**	Ixodidae	*Hyalomma aegyptium*	Testudinata: *Testudo graeca*
			Ixodes ricinus	Sauria: *Lacerta media and Pseudopus apodus*
	Mesostigmata	Macronyssidae	*Ophionyssus saurarum*	Sauria: *Darevskia bithynica* and *Lacerta media*
	Prostigmata	Trombiculidae	*Odontacarus efferus*	Sauria: *Darevskia bithynica*

Table 4. Tick species detected from the reptiles in Türkiye to date.

	Species	Hosts	References
Haemaphysalis	*H. concinna*	Lacertidae: *Apathya* (*A.*) *cappadocica*, *Darevskia* (*D.*) *bendimahiensis*, *D. obscura* (as *D. rudis*), *Eremias suphani,* and *Lacerta* (*L.*) *media* Scincidae: *Ablepharus bivittatus* and *Eumeces schneiderii*	Jabbarpour, 2016
	H. parva	Agamidae: *Stellagama* (*S.*) *stellio*	Aydın et al., 2002
	H. sulcata	Lacertidae: *A. cappadocica*, *L. media*, *Ophisops* (*O.*) *elegans,* and *Timon princeps* Leptotyphlopidae: *Myriopholis macrorhyncha* Scincidae: *Eumeces* (*E.*) *schneideri* and *Trachylepis aurata* Varanidae: *Varanus griseus*	Hoogstraal, 1959; Keskin et al., 2013
	Haemaphysalis sp.	Agamidae: *S. stellio* Lacertidae: *L. trilineata*	Aydın et al., 2002
Hyalomma	*H. aegyptium*	Lacertidae: *Acanthodactylus schreiberi*, *A. cappadocica,* and *D. valentini* Scincidae: *Trachylepis vittata* Testudinidae: *Testudo* (*T.*) *graeca* and *T. hermanni*	Kurtpınar, 1954; Hoogstraal and Kaiser, 1960; Nemenz, 1962; Özkan, 1978; Aydın et al., 2002; Aysul et al., 2010; Kireçci et al., 2013; Yılmaz et al., 2013; Bakırcı, 2016; Jabbarpour, 2016; Yılmaz et al., 2018; Uslu et al., 2019
	H. marginatum	Testudinidae: *Testudo graeca*	Uslu et al., 2019
	Hyalomma sp.	Agamidae: *S. stellio*	Aydın et al., 2002
Ixodes	*I. ricinus*	Lacertidae: *A. cappadocica*, *D. obscura* (as *D. rudis*), *L. viridis,* and *L. media*	Arthur, 1957; Keskin et al., 2012; Jabbarpour, 2016
	Ixodes sp.	Agamidae: *S. stellio* Lacertidae: *L. trilineata* and *L. viridis*	Aydın et al., 2002
Rhipicephalus	*R. annulatus*	Lacertidae: *A. cappadocica* Scincidae: *E. schneiderii* and *O. elegans*	Jabbarpour, 2016

	R. kohlsi	Chamaeleonidae: *Chamaeleo chamaeleon*	Yaman and Zerek, 2016
	R. turanicus	Testudinidae: *Testudo graeca*	Uslu et al., 2019

Table 5. Mite species detected on the reptiles in Türkiye to date.

	Species	Hosts	References
Acaridae	*Acarus farris*	Scincidae: *Ablepharus chernovi*	Jabbarpour, 2016
	Tyrophagus putrescentia	Eublepharidae: *Eublepharis angramainyu* Gekkonidae: *Mediodactylus heterocercum* Lacertidae: *Acanthodactylus* (*A*) *schreiberi*, *Apathya cappadocica, Darevskia* (*D.*) *dryada, D. parvula, D. obscura* (as *D. rudis*), *Lacerta* (*L.*) *viridis,* and *Ophisops* (*O.*) *elegans*	
Anystidae	*Erythracarus parietinus*	Gekkonidae: *Hemidactylus turcicus* Lacertidae: *A. schreiberi* and *O. elegans*	
Glycyphagidae	*Lepidoglyphus destructor*	Gekkonidae: *Hemidactylus turcicus*	
Ixodorhynchidae	*Hemilaelaps piger*	Colubridae: *Natrix natrix*	Feider and Solomon, 1959
Laelaptidae	*Haemolaelaps* sp.	Gekkonidae: *Hemidactylus turcicus*	Jabbarpour, 2016
Macronyssidae	*Ophionyssus natricis*	Colubridae: *Natrix tessellata* Gekkonidae: *Hemidactylus turcicus* Lacertidae: *Apathya cappadocica, D. bendimahiensis, D. obscura* (as *D. rudis*), *D. valentini, Eremias strauchi,* and *Phoenicolacerta laevis*	Dik, 2012; Jabbarpour, 2016
	Ophionyssus saurarum	Gekkonidae: *Hemidactylus turcicus* and *Stenodactylus grandiceps* Lacertidae: *Acanthodactylus schreiberi, Apathya cappadocica, D. armeniaca, D. bendimahiensis, D. clarkorum, D. dryada, D. raddei, D. obscura* (as *D. rudis*), *D. unisexualis, D. uzzelli, L. agilis, L. media, L. trilineata, L. viridis, O. elegans, Parvilacerta parva, Phoenicolacerta laevis,* and *Podarcis siculus* Scincidae: *Ablepharus chernovi* and *Eumeces schneiderii*	Jabbarpour, 2016
	Ophionyssus sp.	Gekkonidae: *Hemidactylus turcicus* and *Stenodactylus grandiceps* Lacertidae: *Apathya cappadocica, D.dryada, L. viridis, O. elegans, Parvilacerta parva, Phoenicolacerta laevis,* and *Podarcis muralis*	Jabbarpour, 2016

Pterygosomatidae	*Geckobia tarantula*	Gekkonidae: *Hemidactylus turcicus* Lacertidae: *Apathya cappadocica*	Jabbarpour, 2016
	Geckobia turkestana	Gekkonidae: *Asaccus barani, Cyrtopodion scabrum*, and *Hemidactylus turcicus* Lacertidae: *Apathya cappadocica* and *D. dryada*	
	Geckobia sp.	Gekkonidae: *Cyrtopodion scabrum* and *Eublepharis angramainyu*	
	Pimeliaphilus desertus	Gekkonidae: *Asaccus barani, Cyrtopodion scabrum, Hemidactylus turcicus* and *Mediodactylus heterocercum* Lacertidae: *Apathya cappadocica*	
Tetranychidae	*Petrobia latens*	Lacertidae: *Darevskia armeniaca*	Jabbarpour, 2016
Trombiculidae	*Lacertacarus callosus*	Gekkonidae: *Stenodactylus grandiceps* Lacertidae: *Anatololacerta pelasgiana, D. parvula, L. trilineata, L. viridis, Phoenicolacerta laevis*, and *Podarcis siculus*	Jabbarpour, 2016
	Lacertacarus similis	Gekkonidae: *Asaccus barani, Cyrtopodion scabrum, Hemidactylus turcicus, Stenodactylus grandiceps*, and *Trapelus lessonae* Lacertidae: *Acanthodactylus boskianus, Anatololacerta danfordi, Apathya cappadocica, D. bendimahiensis, D. clarkorum, D. dryada, D. obscura* (as *D. rudis*), *D. parvula, D. uzzelli, Eremias strauchi, L. agilis, L. media, L. trilineata, O. elegans*, and *Podarcis muralis* Scincidae: *Eumeces schneiderii*	
	Lacertacarus turcicus	Lacertidae: *Lacerta* spp.	Kalúz, 2011
	Matacarus demrei	Eublepharidae: *Eublepharis angramainyu* Gekkonidae: *Asaccus barani* Lacertidae: *Lacerta viridis, Ophisops elegans*, and *Podarcis muralis*	Kepka, 1962; Jabbarpour, 2016
	Matacarus sp	Lacertidae: *Podarcis siculus*	
	Neotrombicula autumnalis	Gekkonidae: *Hemidactylus turcicus*	
	Neotrombicula sp.	Lacertidae: *Anatololacerta pelasgiana*	

Table 6. Mite species detected on the pet reptiles in Türkiye to date.

	Species	Hosts	References
Macronyssidae	*Ophionyssus natricis*	Boidae: *Boa constrictor* Colubridae: *Pantherophis guttatus*	Kurtdede et al., 2009; Keskin, 2021
Pterygosomatidae	*Hirstiella* sp.	Iguanidae: *Iguana iguana*	Gazyağcı et al., 2011; Yipel, 2014

APPENDIX II: Ectoparasitic infestations detected on the examined reptile hosts

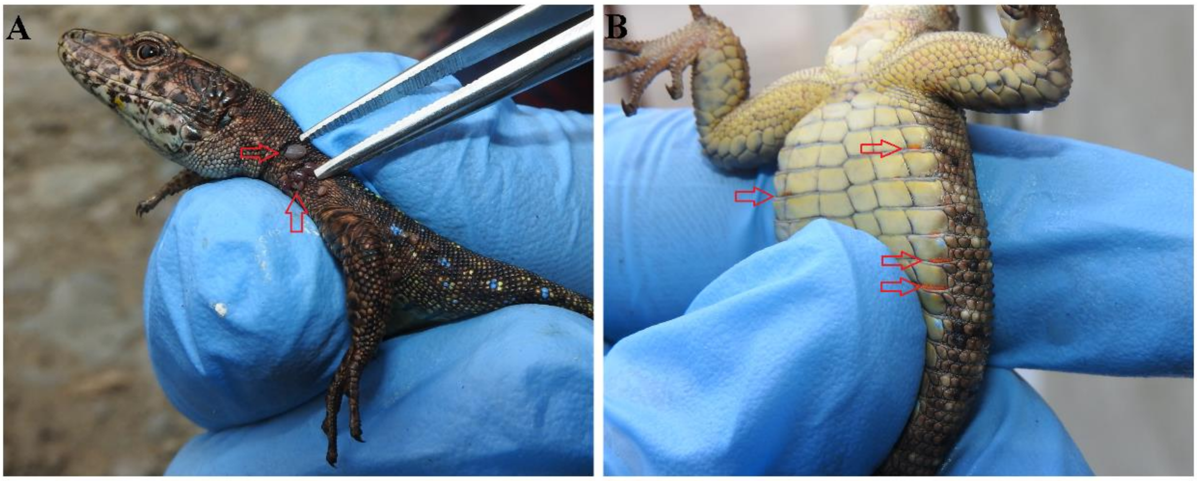

Figure 1. Ectoparasite infestation on hosts: **A.** *Darevskia obscura* (from Borçka, Artvin), **B.** *Darevskia clarkorum* (from Borçka, Artvin) (red arrows: mite specimens on the right, and ticks in the larval and nymph stages on the left).

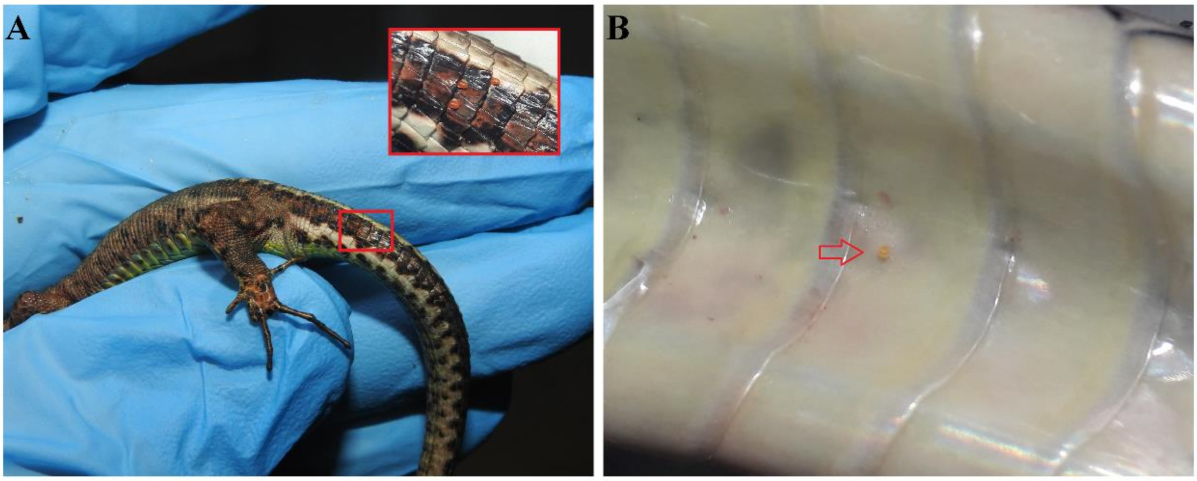

Figure 2. Ectoparasite infestation on hosts: **A.** *Darevskia derjugini* (from Borçka, Artvin), **B.** *Platyceps najadum* (from Borçka, Artvin) (red rectangles and arrow: trombiculid specimens).

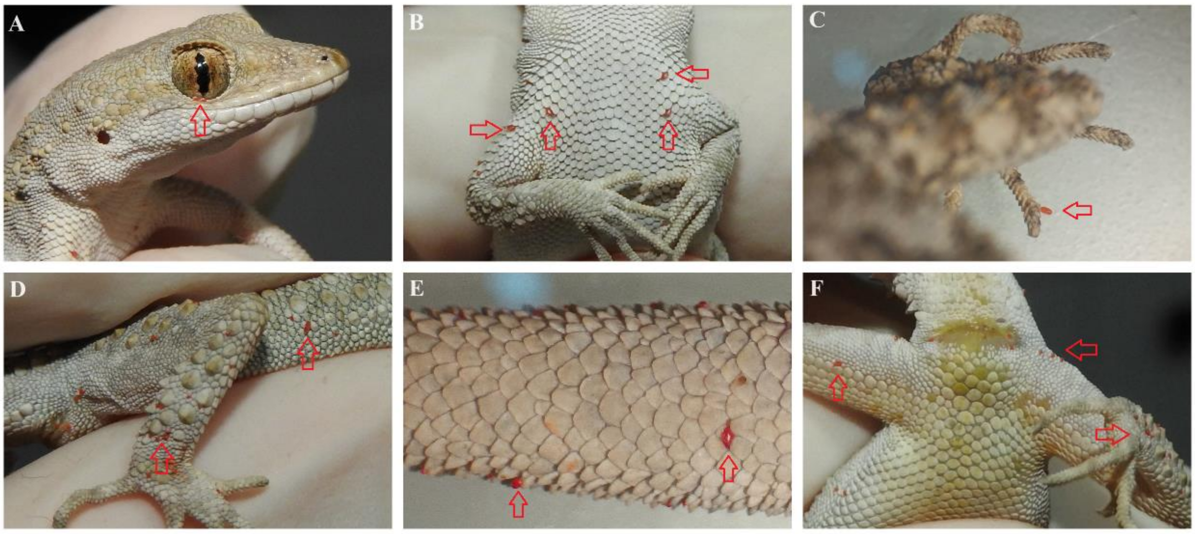

Figure 3. *Geckobia turkestana* (red arrows) on the Kotschy`s Gecko (*Mediodactylus* cf. *kotschyi*) (from Ardanuç, Artvin).

Figure 4. Ectoparasite infestation on lacertid hosts (red arrows show *Ixodes ricinus* larvae and nymphs).

Figure 5. Ectoparasite infestation on lacertid and anguid hosts (red arrows show *Ixodes ricinus* larvae and nymphs).

Figure 6. *Hyalomma aegyptium* infestation on *Testudo graece* (from Atakum, Samsun, Türkiye).

Appendix III: The images of the detected ectoparasites (ticks and mites)

Figure 7. *Ophionyssus saurarum* (protonymph): **A.** Dorsal view (scale bar: 250 µm), **B.** Pygidial plate (scale bar: 50 µm), **C.** Anus (scale bar: 25 µm).

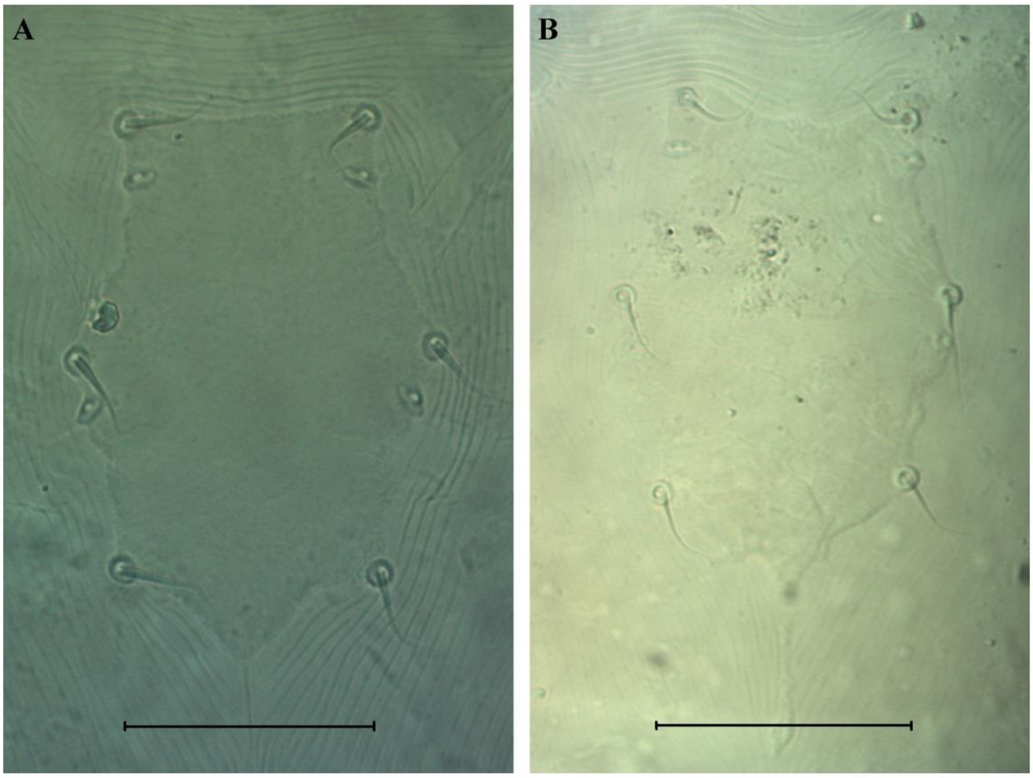

Figure 8. A. Sternal shields: **A.** *Ophionyssus natricis* (protonymph), **B.** *Op. saurarum* (protonymph) (scale bars: 50 µm).

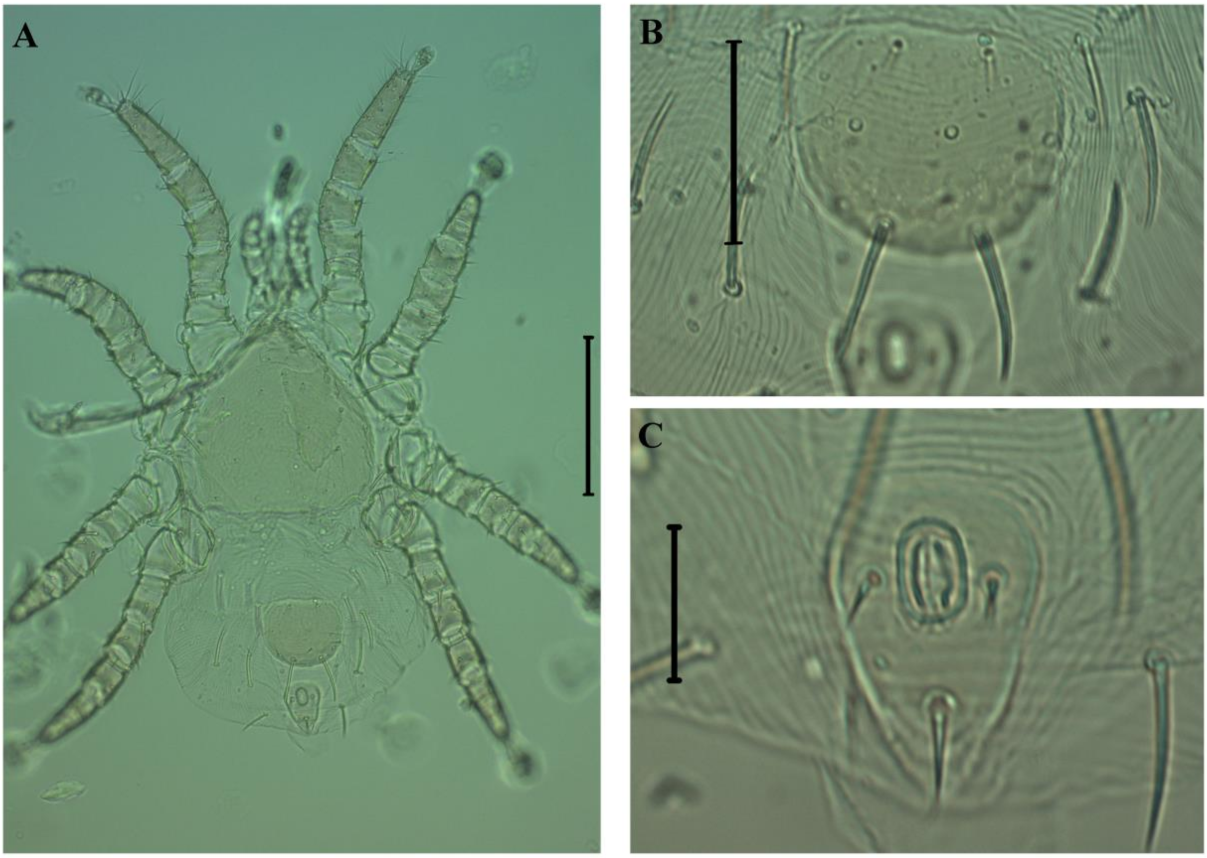

Figure 9. *Ophionyssus saurarum* (protonymph): **A.** Dorsal view (scale bar: 250 µm), **B.** Pygidial plate (scale bar: 50 µm), **C.** Anus (scale bar: 25 µm).

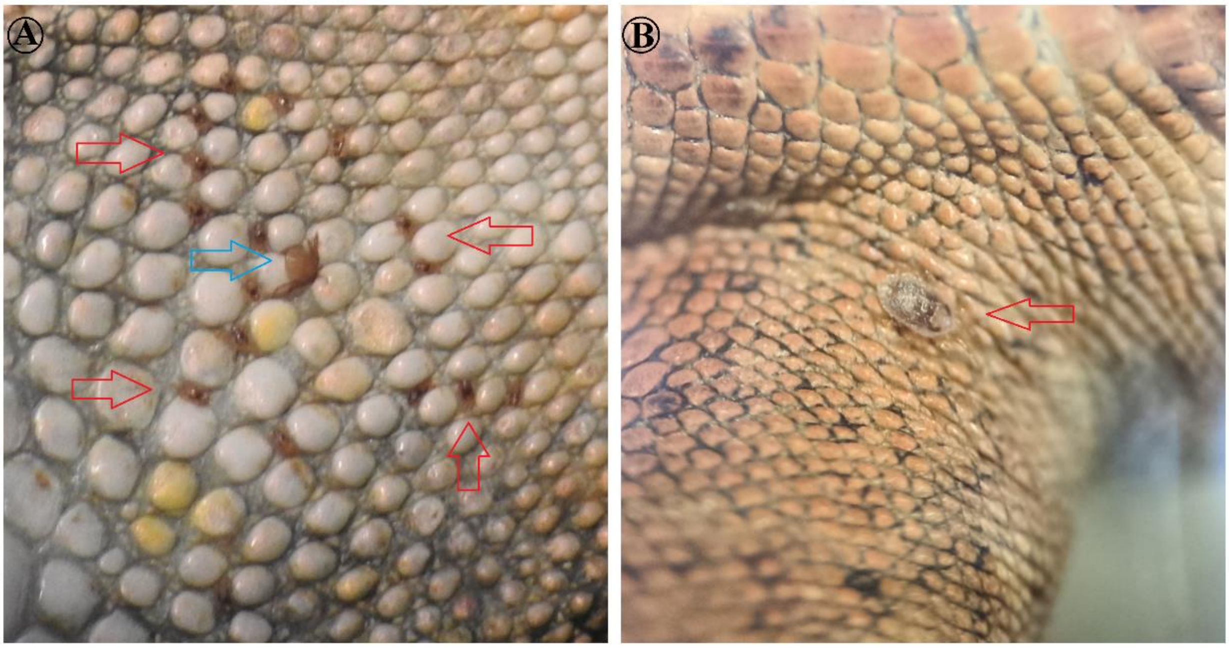

Figure 10. A. Protonymph specimens of *Ophionyssus saurarum* on the spiny-tailed lizard (*Darevskia obscura*), **B.** The same specimens on the green lizard (*Lacerta viridis*) (red arrows: mite specimens; blue arrow: ticks in the larval stage).

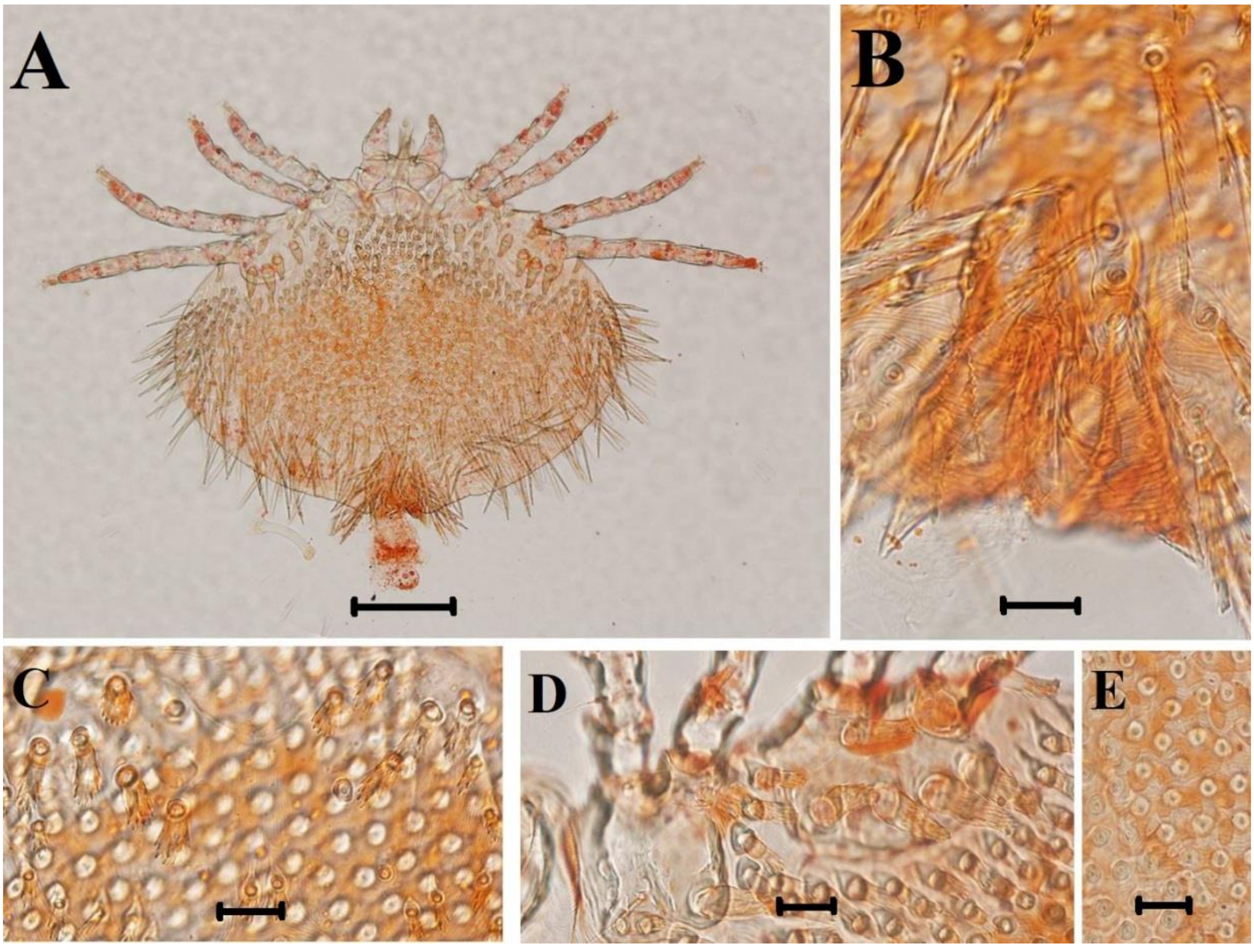

Figure 11. *Geckobia turkestana* (♀): **A.** Dorsal view (scale bar: 100 μm), **B.** Genital region (scale bar: 100 μm), **C.** Scutum (scale bar: 100 μm), **D.** Coxae I-IV (scale bar: 100 μm), **E.** Ventral setae (scale bar: 50 μm).

Figure 12. A. Larval specimens of *Lacertacarus similis* (red arrows) on the Artvin lizard (*Darevskia derjugini*), **B.** The same specimens on the Adjara lizard (*Darevskia adjarica*).

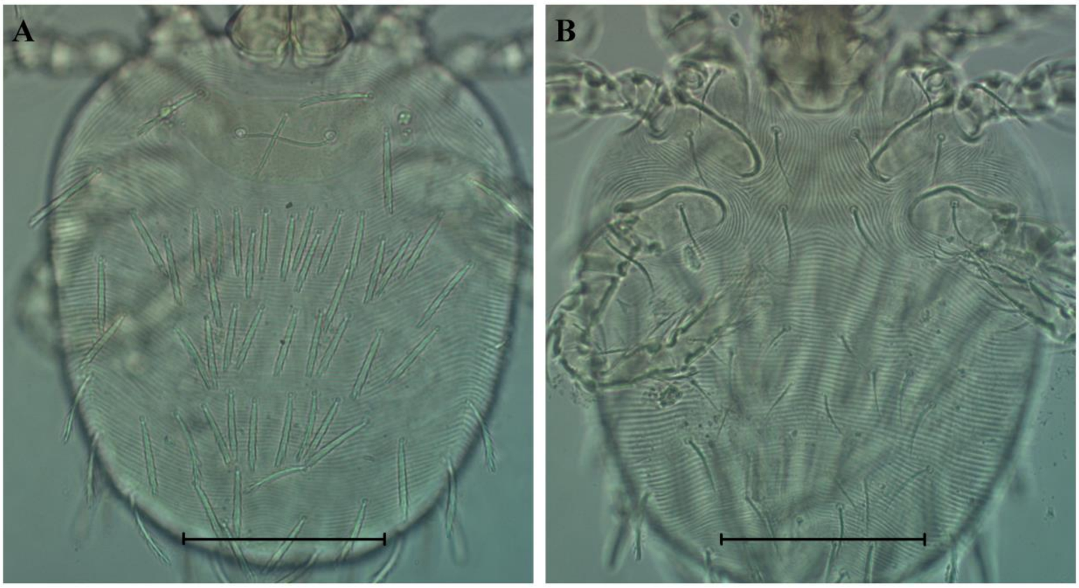

Figure 13. *Lacertacarus callosus* (larva): **A.** Dorsal view of idiosoma, **B.** Ventral view of idiosoma (scale bars: 100 μm).

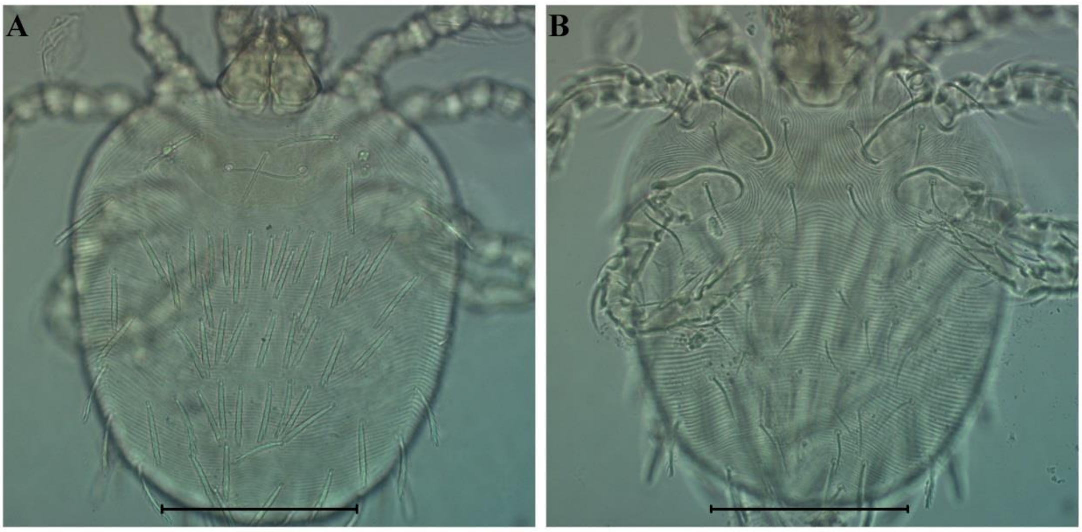

Figure 14. *Lacertacarus similis* (larva): **A.** Dorsal view of idiosoma, **B.** Ventral view of idiosoma (scale bars: 100 μm).

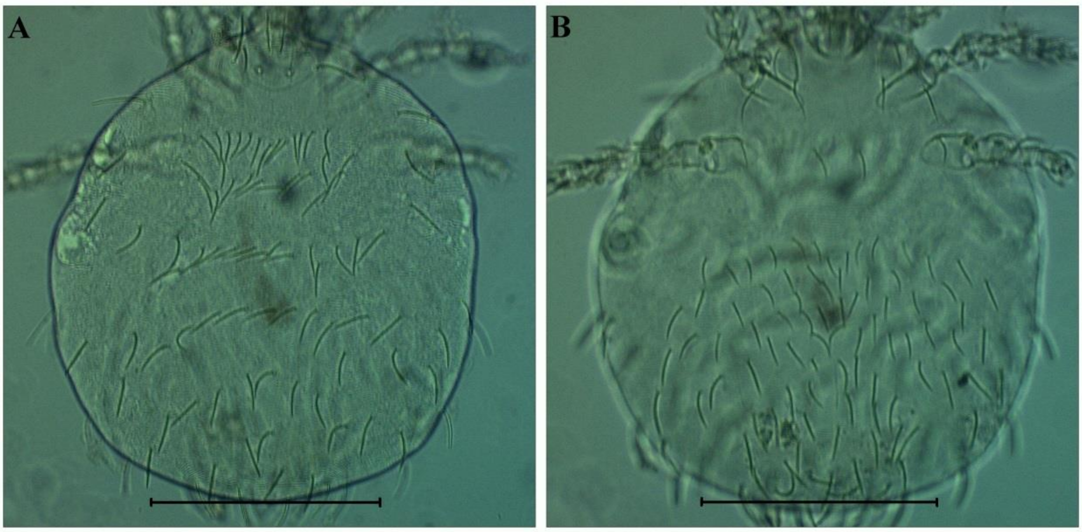

Figure 15. *Odontacarus efferus* (larva): **A.** Dorsal view of idiosoma, **B.** Ventral view of idiosoma (scale bars: 250 μm).

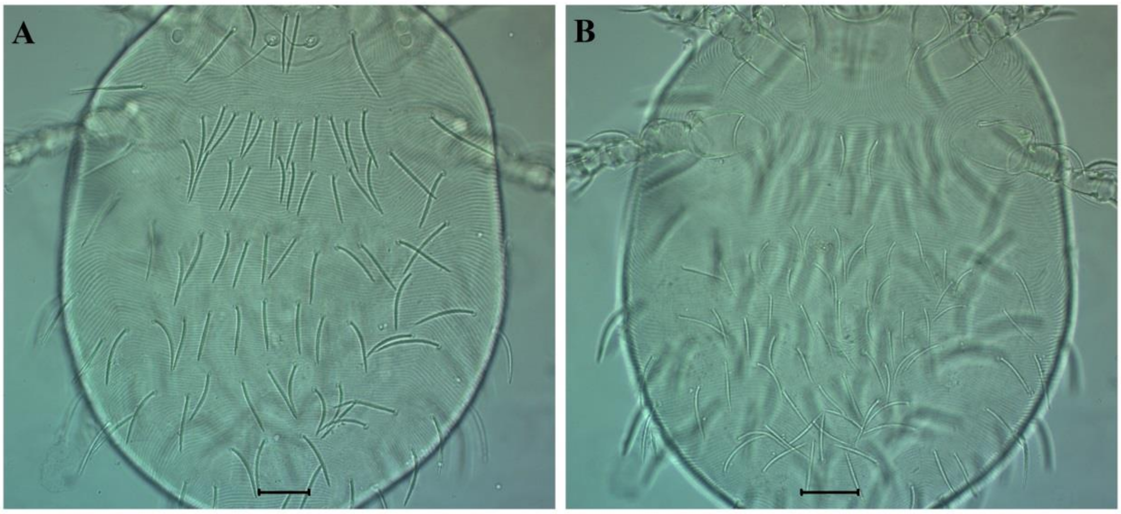

Figure 16. *Odontacarus hushchai* (larva): **A.** Dorsal view of idiosoma, **B.** Ventral view of idiosoma (scale bars: 250 µm).

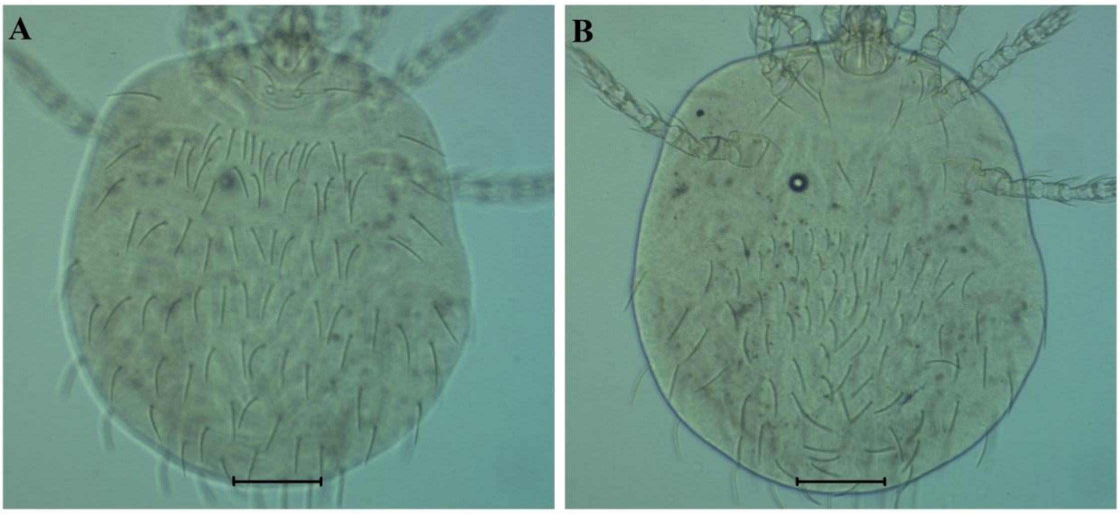

Figure 17. *Odontacarus naumovi* (larva): **A.** Dorsal view of idiosoma, **B.** Ventral view idiosoma (scale bars: 250 µm).

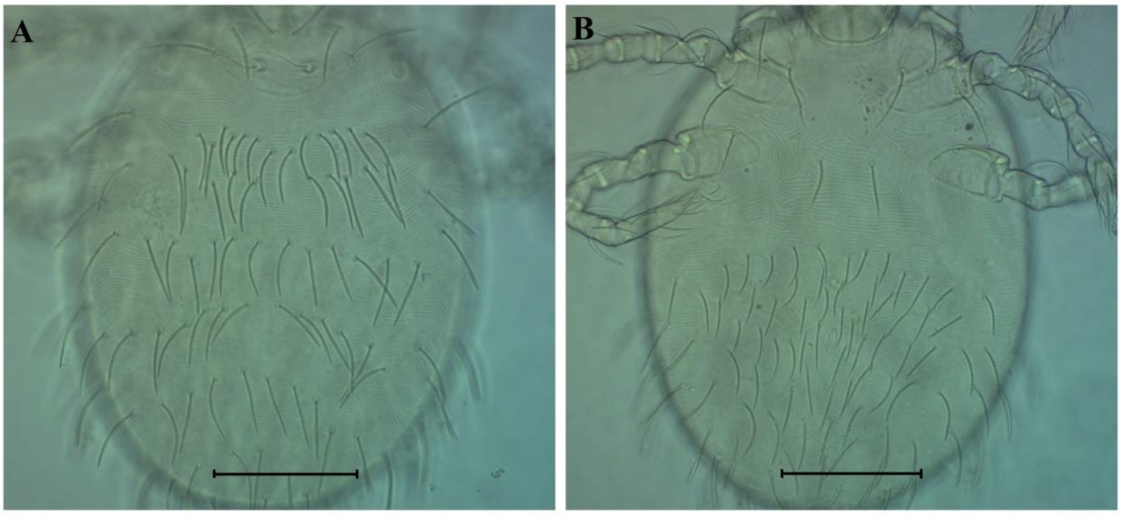

Figure 18. *Odontacarus saxicolis* (larva): **A.** Dorsal view of idiosoma, **B.** Ventral view of idiosoma (scale bars: 250 µm).

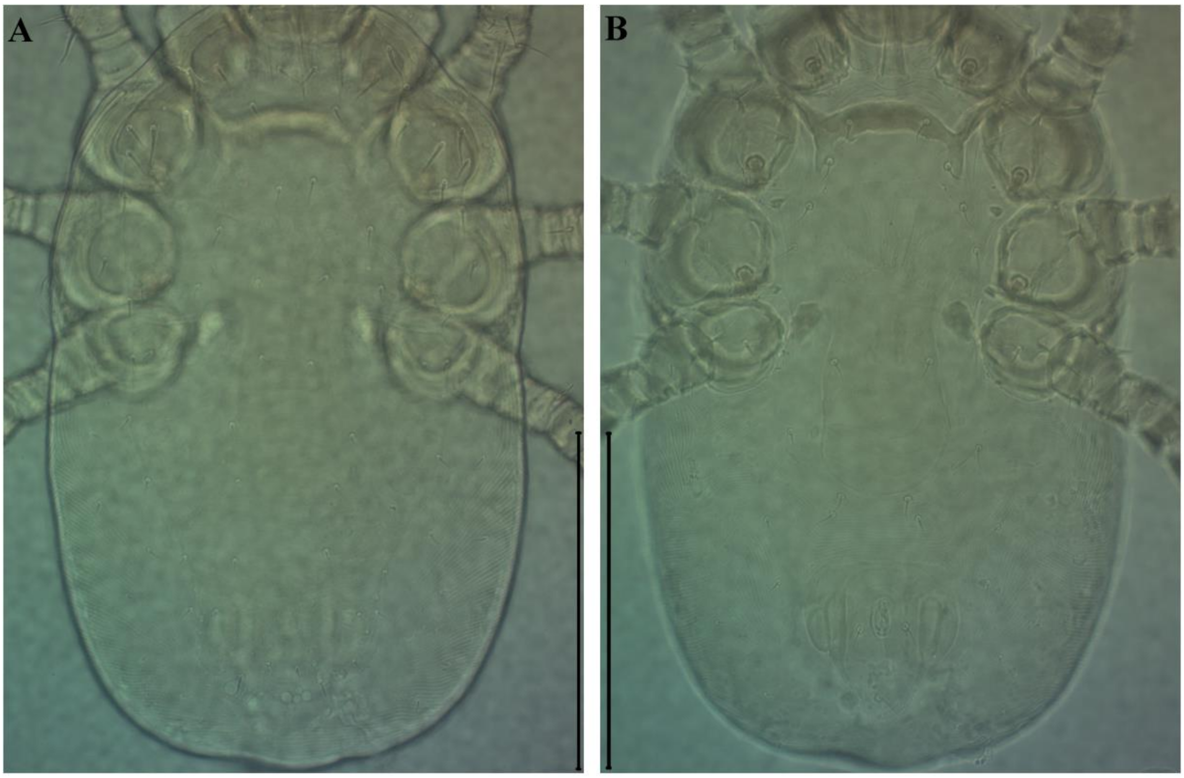

Figure 19. *Hemilaelaps farrieri*: **A.** Dorsal view of idiosoma, **B.** Ventral view of idiosoma (scale bar: 250 µm).

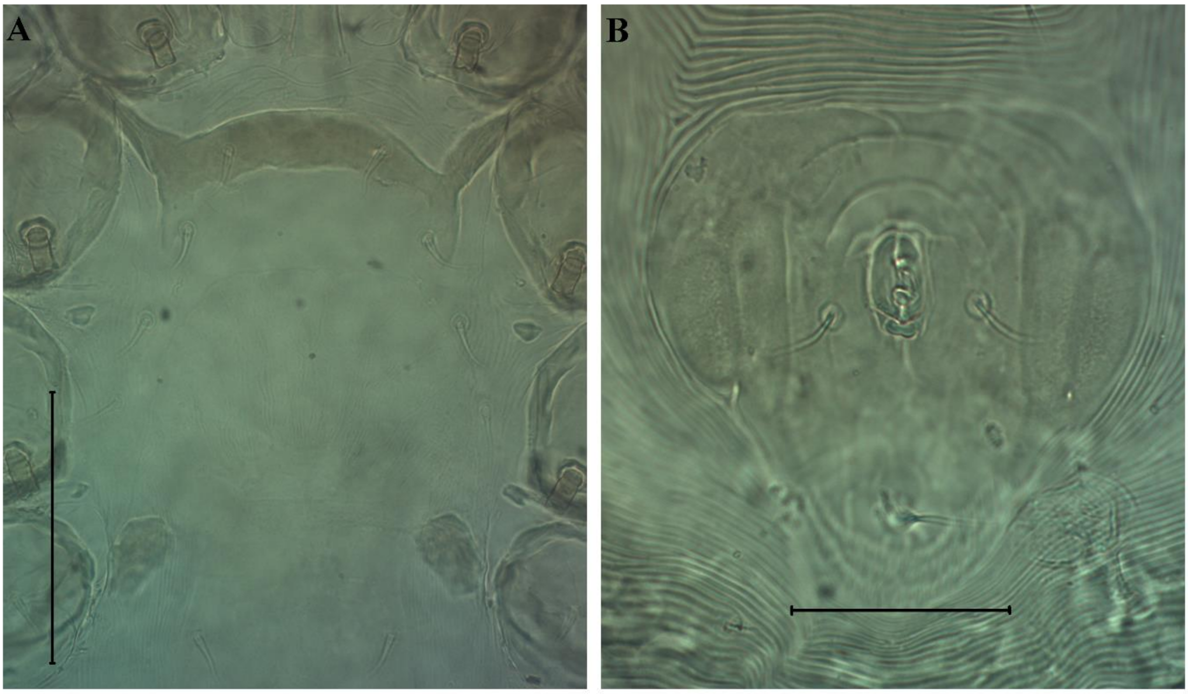

Figure 20. A. *Hemilaelaps farrieri*: **A.** Dorsal view of idiosoma (scale bar: 100 µm) **B.** Anus (scale bar: 50 µm).

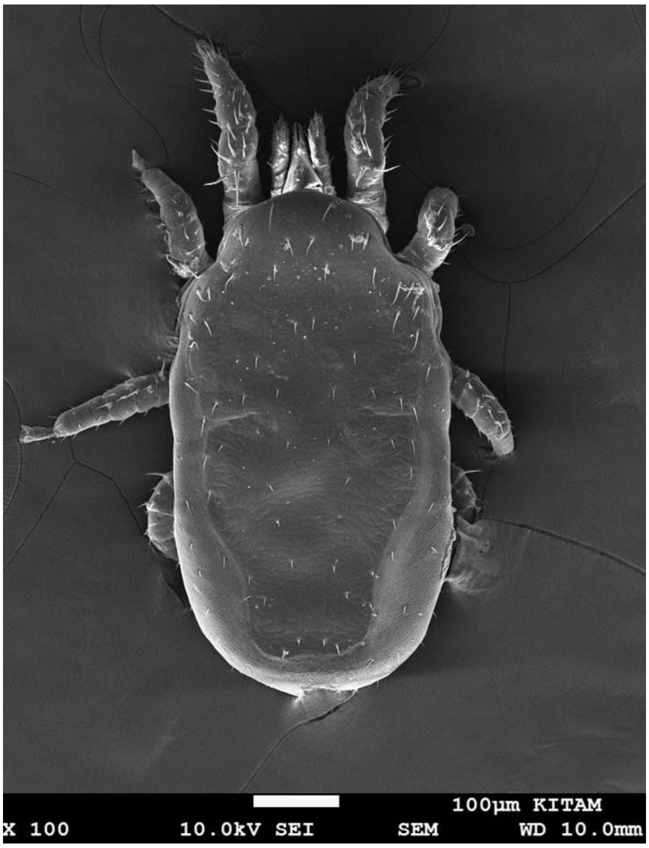

Figure 21. SEM image of *Hemilelaps farrieri* (♀): dorsal view.

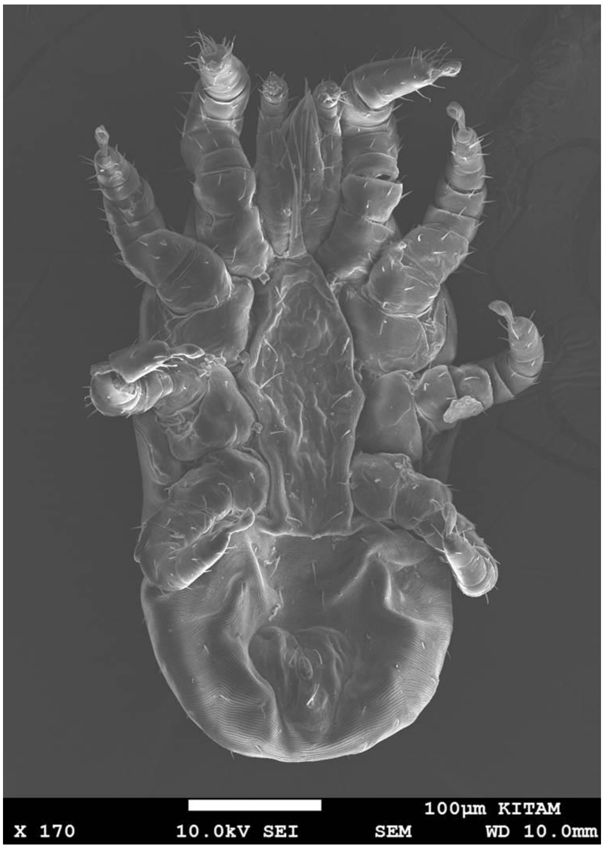

Figure 22. SEM image of *Hemilelaps farrieri* (♀): ventral view.

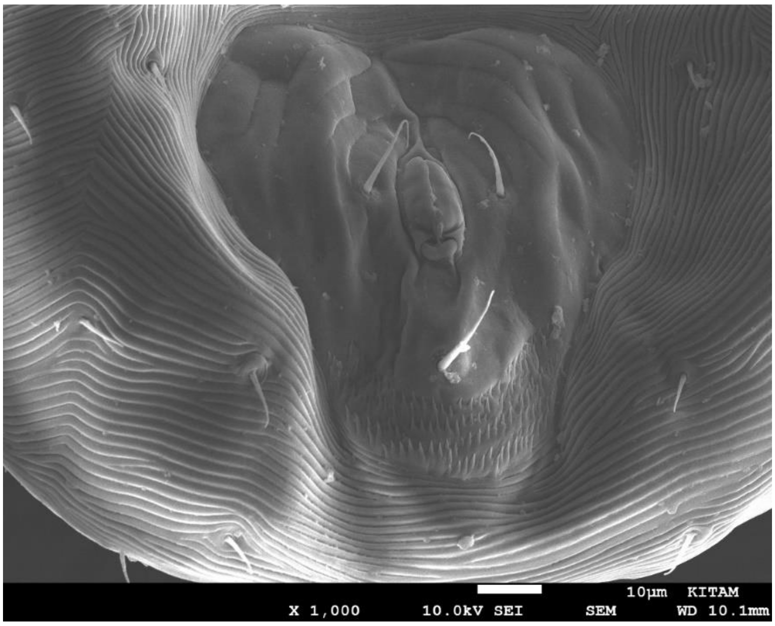

Figure 23. SEM image of *Hemilaelaps farrieri* (♀): anal plate.

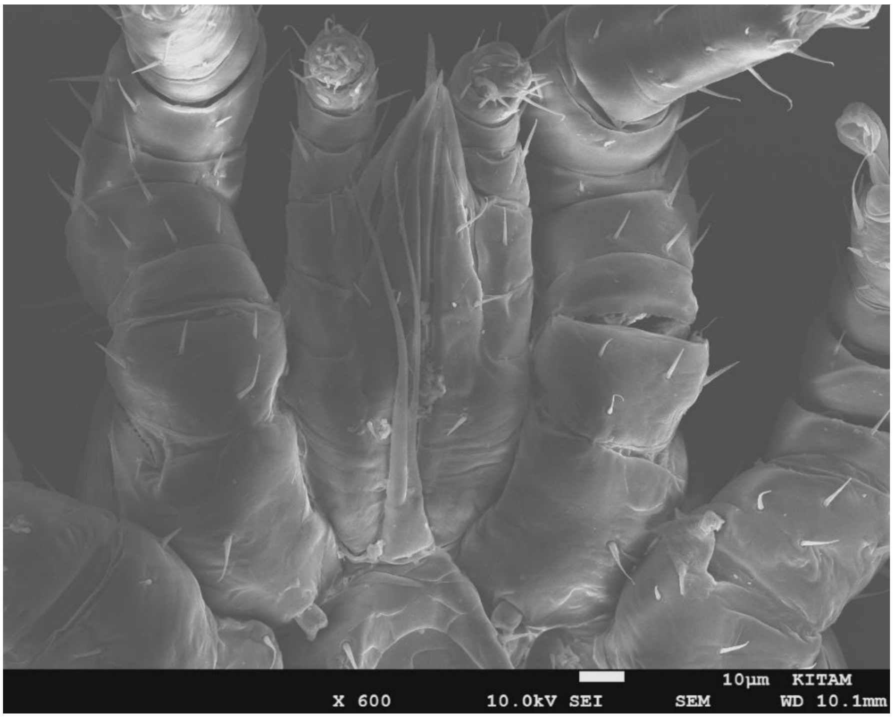

Figure 24. SEM image of *Hemilaelaps farrieri* (♀): tritosternum.

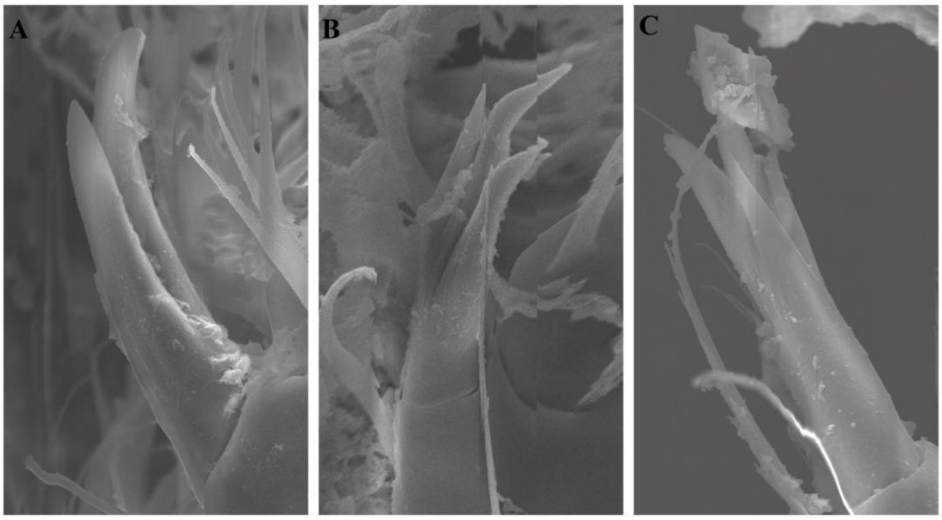

Figure 25. SEM image of *Odontacarus* palpal claw numbers: **A.** *O. efferus*, **B.** *O. naumovi*, **C.** *O. hushchai*.

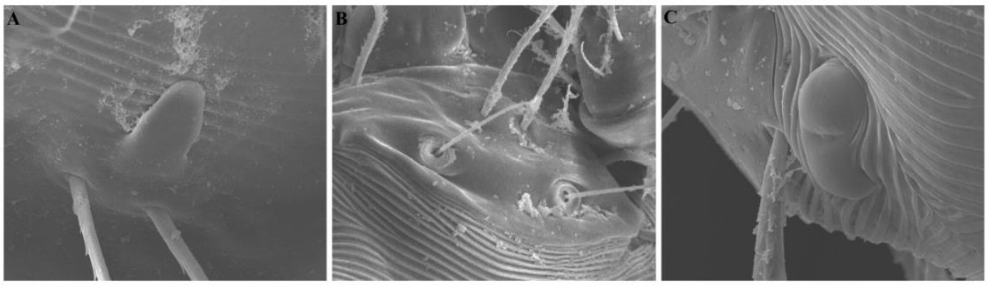

Figure 26. SEM images of nasus, scutum, and eye structures of *Odontacarus naumovi.*

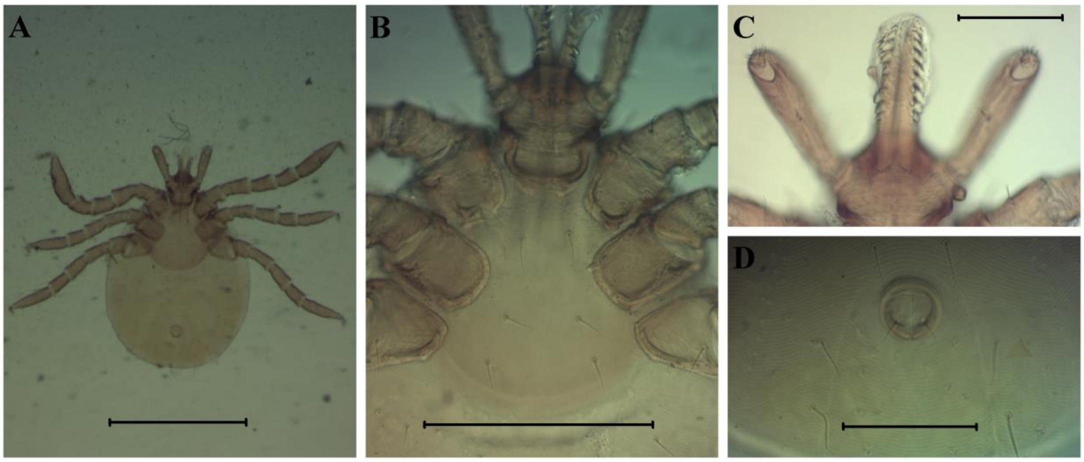

Figure 27. A. *Ixodes ricinus* larva (scale bar: 500 µm), **B.** Coxae I-III and basis caputili (scale bar: 250 µm), **C.** Hypostome (scale bar: 100 µm), **D.** Anal groove (scale bar: 100 µm).

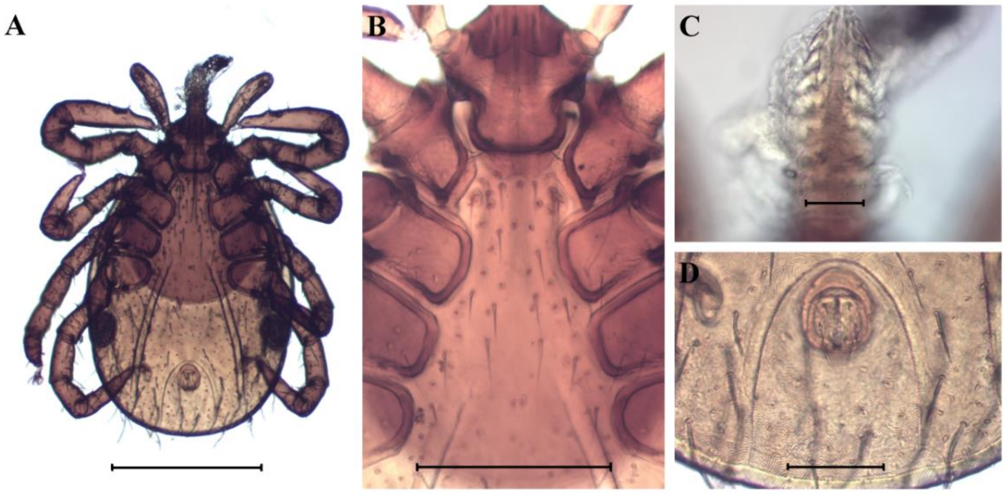

Figure 28. A. *Ixodes ricinus* nymph (scale bar: 1000 µm), **B.** Coxae I-III and basis caputuli (scale bar: 250 µm), **C.** Hypostome (scale bar: 100 µm), **D.** Anal groove (scale bar: 100 µm).

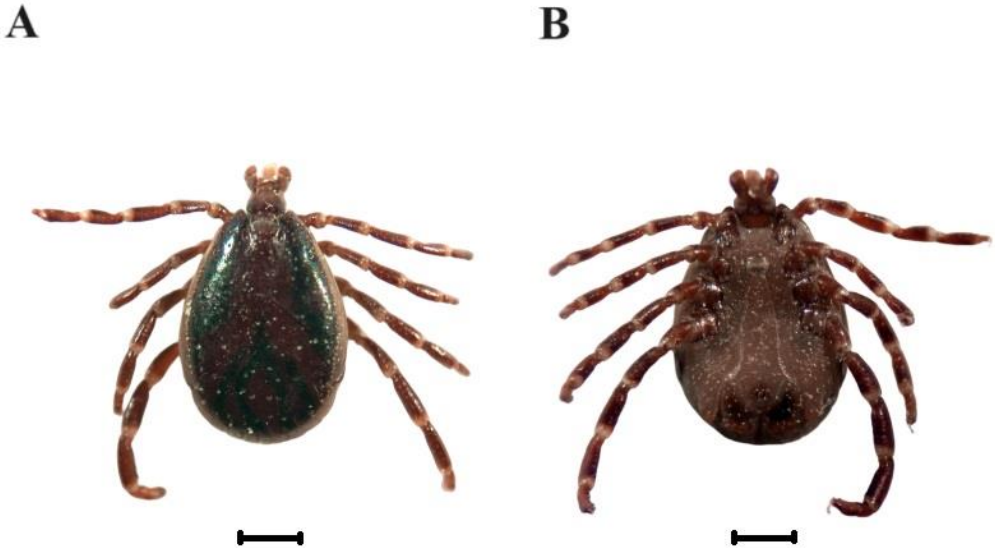

Figure 29. *Hyalomma aegyptium* (♂): **A.** Dorsal, **B.** Ventral (scale bars: 1 mm).

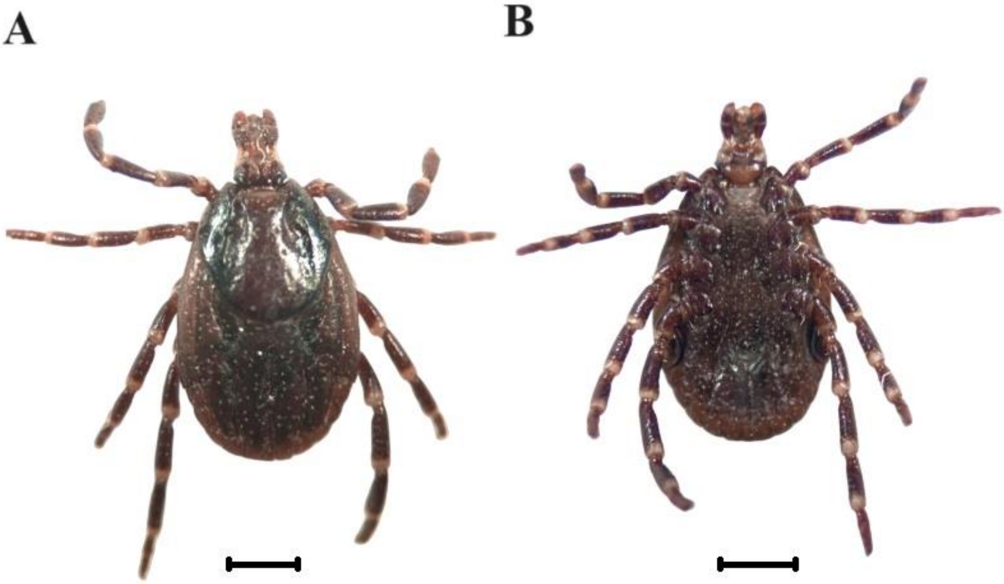

Figure 30. *Hyalomma aegyptium* (♀): **A.** Dorsal, **B.** Ventral (scale bars: 1 mm).

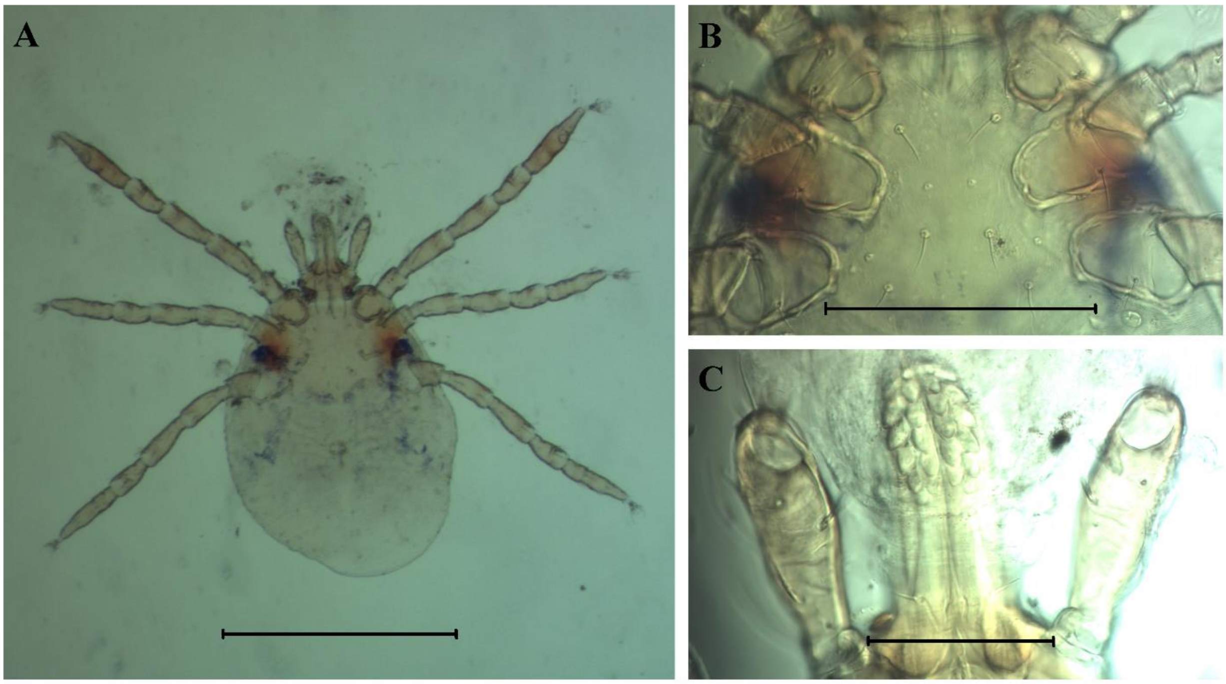

Figure 31. A. *Hyalomma aegyptium* larva (scale bar: 500 µm), **B.** Coxae I-III (scale bar: 250 µm) and **C.** Hypostome, (scale bar: 100 µm) collected from the Balkan wall lizard (*Podarcis tauricus*).