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OPINION ARTICLE

# The trashing of treasure: global biodiversity needs intensive care

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**ASBTRACT:** Continuing population declines and extinctions across the earth's biodiversity spectrum further undermine global ecological functioning and the security of human society. A comprehensive summary of the soon to be released Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Nexus Assessment report was published in December 2024. It stated that the current environmental, social and economic crises, reflected in mounting biodiversity loss, global climate change, growing water and food insecurity and risks to human health, are inseparable. It also warned that biodiversity levels have fallen between 2% and 6% per decade for the last 30 to 50 years. The level of harm being inflicted on nature is chilling for human society given that the report also stated that ~$58 trillion of global economic activity in 2023 was in sectors moderately to highly nature dependent. Setting aside the strong moral arguments for biodiversity conservation, this situation points to a mounting economic disaster. On a positive note, the report summary did list a suite of proposals for slowing this alarming level of biodiversity loss. However, separate from the IPBES Nexus report, factors that need to be addressed include the expectation of continuous economic growth, extreme concentration of global wealth and power; economic materialism; corporate tax avoidance; public and private sector corruption; the non-incorporation of environmental costs in generating Gross Domestic Product; and the flooding of the internet with misinformation, including climate change denial.

**Keywords:** Ecosystem collapse, Red List of Threatened Species, Greenland ice cap, poverty, renewable energy, invertebrate extinctions, mite
**Zoobank:** https://zoobank.org/5FBEDF8D-D404-4C8D-87EE-2CBD31C413B3

Numerous reports have highlighted the loss of biodiversity globally (Carson, 1962; Wilson, 1985; Diamond, 1989; Stork and Lyal, 1993; Pimm and Raven, 2000; Thomas et al., 2004; Dickman et al., 2007; Dunn et al., 2009; Ripple et al., 2017; Kehoe et al. 2021; Raven and Wagner, 2021; Harvey et al. 2023; Boyle et al. 2024; Woinarski et al. 2024; Carluccio et al. 2025), including mites (Winchester and Ring, 1996; Carlson et al., 2017; Napierala et al., 2018; Elo and Sorvari, 2019; Sullivan and Ozman-Sullivan, 2021, 2022; Seeman, 2022; Ozman-Sullivan and Sullivan, 2023; Ozman-Sullivan et al., 2024).

The mounting environmental, social and economic costs of biodiversity loss across the world (Ehrlich and Ehrlich, 1981; Cardinale et al., 2012; Ripple et al., 2017; Carrington, 2018; OECD, 2019; Bradshaw et al., 2021; Sullivan and Ozman-Sullivan, 2022, 2023) were put in a holistic context in a comprehensive summary of the most recent Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Nexus Assessment report released in December 2024 in Windhoek, Namibia (the full report is to be issued in 2025). The IPBES Plenary, composed of representatives of the 147 governments that are members of IPBES, endorsed the full report, which was the product of three years of collaborative, interdisciplinary work by 165 experts from 57 countries from all regions of the world (Anonymous, 2024).

In brief, the IPBES Nexus report summary (Anonymous, 2024) stated that the current environmental, social and economic crises, reflected in mounting biodiversity loss, growing water and food insecurity, health risks and climate change, are intimately interconnected. Furthermore, they compound each other in ways that can make separate efforts to address them both ineffective and counterproductive.

The year 2024 was the first in which the average global temperature was clearly 1.5 °C above the pre-industrial average, a threshold established by the Paris Agreement to restrict the risks and impacts associated with climate change (Anonymous, 2025a). Arrival at this tragic milestone has sharpened the focus on the growing environmental crisis because climate change is also a key contributor to biodiversity loss (Thomas et al., 2004). In response to this dire situation, McGuire and Hallam (2025) challenged scientists to act urgently in an article titled "Scientists prize neutrality – that doesn't cut it anymore. In 2025, they must fully back the climate movement".

According to the IPBES Nexus report summary (Anonymous, 2024), biodiversity, the richness and variety of all life on Earth, continues to decline globally, regionally and locally. More specifically, biodiversity levels have dropped by 2% to 6% every 10 years across multiple indicators for the last 30 to 50 years. Setting aside any moral arguments for biodiversity conservation, this continuing tragic loss of biodiversity could be described politely as economic suicide since the report stated that ~$58 trillion of global economic activity in 2023 was in sectors moderately to highly dependent on what nature provides. Furthermore, the report summary stated that up to $25 trillion of negative impacts on biodiversity, climate, water resources and public health were not considered in decision-making in the fossil fuel, agriculture and fisheries sectors.

Urgently arresting the continuing biodiversity, climate and poverty/social justice crises is an enormously complex but not impossible challenge. Many government agencies, indigenous groups, NGOs, academic institutions, businesses, local groups and journalists across the world are making valuable contributions to public education and biodiversity conservation and the halting of climate change.

The summary of the IPBES Nexus Report (Anonymous, 2024) lists 70 political and community level responses, including some low cost responses that can reduce the intensity of the current crisis. Furthermore, some of the response options can have broad, positive impacts. They include the restoration of carbon-rich ecosystems such as forests, including mangroves, and degraded soils; better integration of landscape and seascape management; urban nature-based solutions; sustainable, healthy diets; and supporting indigenous food systems.

Earlier, Ripple et al. (2017), in the landmark publication, "World Scientists' Warning to Humanity; A Second Notice", documented the dimensions of the growing global environmental crisis and outlined numerous measures that need to be urgently adopted in response.

Bradshaw et al. (2021) asserted that the global environmental emergency requires fundamental changes to global capitalism, education programs and society, including the abandonment of the focus on perpetual economic growth; social equality; a rapid transition from fossil-fuel use to renewable energy sources; and the empowerment of minority and disadvantaged groups in all societies.

Stehfest et al. (2009) stated that the livestock sector accounts for 18% of greenhouse gas emissions and 80% of human land use. They argued that a global shift to a less meat-based diet, or even a complete transition to a plant-based diet, would free up 2.7 billion hectares of pastureland and 100 million hectares of cropland for revegetation and greatly reduce the production of methane and nitrous oxide, both potent greenhouse gases. They concluded that this dietary change would substantially improve global land use and human health and play a major role in climate change mitigation.

Other actions that would substantially contribute to saving the great majority of the world's remaining biodiversity include: the protection of natural and semi-natural habitats, especially the subtropical and tropical forests; habitat restoration with local species; management of soils as a vast carbon sink; minimization of air, water and soil pollution; a reduced human population; and the sustainable use of global resources (Sullivan and Ozman-Sullivan, 2022).

Achieving urgent biodiversity and climate change goals is also being slowed by factors such as the growth of populism, nationalism and authoritarianism; an identity crisis in 'democracies'; public and private sector corruption; widespread ignorance of the extreme consequences of the current 'business as usual' approach; lack of environmental education in schools; hundreds of thousands of academics not taking enough responsibility for social change; corporate tax avoidance; vast and increasing military expenditure; regional wars; growing disrespect for the United Nations and its institutions; increasing disregard for facts as a basis for decision making; gender discrimination; enormous wealth and resource use differences between the global rich elite and the huge masses of humanity in grinding poverty; the non-incorporation of environmental costs in generating Gross Domestic Product; non-enforcement of national and international laws to protect biodiversity; suppression of environmental activism through violence and oppressive laws; increasing concentration of media ownership; and flooding of the Internet with misinformation by vested interests seeking to sow fear and disharmony. As one example of the horrifically distorted global economy, Anonymous (2025b) reported that the wealth of the world's billionaires grew by two trillion dollars in 2024, amounting to 5.7 billion dollars per day, which was three times faster than in the previous year.

The enormous and complex social, political and economic challenges to biodiversity conservation, climate stabilisation, sustainability and social justice can only be overcome by a huge, brave, collective, on-going effort worldwide. We can all contribute by consciously minimizing our ecological footprints in all aspects of our daily lives and through active support of biodiversity conservation, renewable energy and social justice initiatives.

## Authors' contributions

**Gregory T. Sullivan:** Conceptualisation (equal), writing - original draft (lead), writing – editing after review (equal). **Sebahat K. Ozman-Sullivan:** Conceptualisation (equal), writing - original draft (support), writing – editing after review (equal).

## Statement of ethics approval

Not applicable.


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## Conflict of interest

The authors declare that they have no conflicts of interest regarding this paper.


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RESEARCH ARTICLE

# *Rhinella alata* (Anura: Bufonidae), *Tityus jaimei* and *Tityus festae* (Scorpiones: Buthidae) as new carriers of phoretic mites *Archegozetes magnus* (Oribatida: Trhypochthoniidae) in Panama

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**ASBTRACT:** In this paper, we report the mite, *Archegozetes magnus* immatures and females, in non-parasitic interactions with Bishop's Toad, *Rhinella alata* (Anura: Bufonidae), and the Buthidae scorpions *Tityus jaimei* and *Tityus festae*. The reports in both species of scorpions represent news phoretic interactions. Possible behavior is discussed.

**Keywords:** Leaf litter mites, parthenogenetic, scorpions, toad, Central America
**Zoobank:** https://zoobank.org/0CDD86EF-C8F3-4B7B-88E0-58C3319DAB48

## INTRODUCTION

The family Trhypochthoniidae (Oribatid) contains 7 genera, 61 species and 14 subspecies (Subias, 2004, updated 2024). Among these genera, *Archegozetes* is a small genus with a complex taxonomy (Heethoff et al., 2013). In this sense, Subias (2004, updated 2024) recognizes one species, *Archegozetes magnus* (Sellnick) and two subspecies *Archegozetes magnus magnus* (Sellnick) and *Archegozetes magnus longisetosus* Aoki) as valid, considering the other species descripted in the genus as synonyms or subspecies. Thus, *Archegozetes magnus* currently has a wide distribution with reports in America, Asia (continental and insular) and Africa (Badejo et al., 2002).

Similar to other trhypochthoniid, *Archegozetes* mites inhabit soil, leaf litters, decay woods or bark in humid areas as peatlands and feed algae, fungi or even leaves (Palacios-Vargas and Iglesias, 1997; Estrada-Venegas et al., 1999; Smrž and Norton, 2004; Norton and Behan-Pelletier, 2009). Under these conditions, *Archegozetes* subsist together with other groups of vertebrates and invertebrates that live in these environments, promoting different interactions between them. In this sense, *Archegozetes* spp. are reported as prey for vertebrates (McGugan et al., 2016; Salazar-Filippo et al., 2024). Furthermore, phoretic behavior has been reported in *A. magnus*. Townsend et al. (2008) reported *A. magnus* (identified post-publication in Beaty et al., 2013) in a species of *Cynortula* (Opiliones, Cosmetidae) in Trinidad, and later Beaty et al. (2013) reported it on the Leptodactylidae frog *Engystomops pustulosus* (Cope) in Panama. Other reports of carriers of phoretic *A. magnus* include *Triatoma dimidiata* (Latreille) (Hemiptera, Reduviidae) in Yucatan, Mexico (Waleckx et al., 2018), and the Bufonid toad *Rhinella major* Müller and Hellmich in Brazil (Mendoza-Roldán et al., 2020).

In this work, we add new information on invertebrates and vertebrates carrying *A. magnus* in Panama.

## MATERIAL AND METHODS

Mites from the "Dr. Eustorgio Méndez" Zoological Collection (CoZEM-ICGES) of the Gorgas Memorial Institute for Health Research, Panama, were revised. Mites were examined under the stereomicroscope Leica S9D cleared in Nesbitt's fluid and mounting in microscopy slides using Hoyer's medium (Singer, 1967). The mites were photographed with Leica ICC50 E digital camera integrated into the Leica DM750 microscope. The photographs were captured and edited (scale bar) with the Leica Application Suite version 4.13. Darkfield photographs were taken under the Olympus CX43 microscope. The identification was made using the redescription proposed by Badejo et al. (2002).

## RESULTS AND DISCUSSION

*Archegozetes magnus* (Sellinick)

*Materials examined*

14 ♀♀ *ex Rhinella alata* (Thominot); anatomical location: dorsum of head and fore and hind limbs (Fig. 1). PANAMÁ: Darién province. Darien National Park, Rancho Frio Station. 12 June 2017. Coll: Lillian Domínguez, Dmitry Apanaskevich. Note: Not all mites on the toad were collected.

8 ♀♀, 1 nymph *ex Rhinella alata* (Thominot); anatomical location: dorsum of head and fore limbs (Fig. 2). PANAMÁ: Panamá province. Soberanía National Park. 12 June 2023. Coll: Samuel Sucre, Macario González.

4 ♀♀ *ex Tityus jaimei*, Miranda, Bermúdez, Flores and de Armas 2020; anatomical location: dorsum of segments I and II of metasoma and leg IV (Fig. 3). PANAMÁ: Veraguas province, Santa Fe, Las Filipinas, 23 June 2017, *ex Tityus jaimei* male, coll. Roberto Miranda, Ingrid Murgas, Juan "Largo" Lezcano, Lyska Castillo.

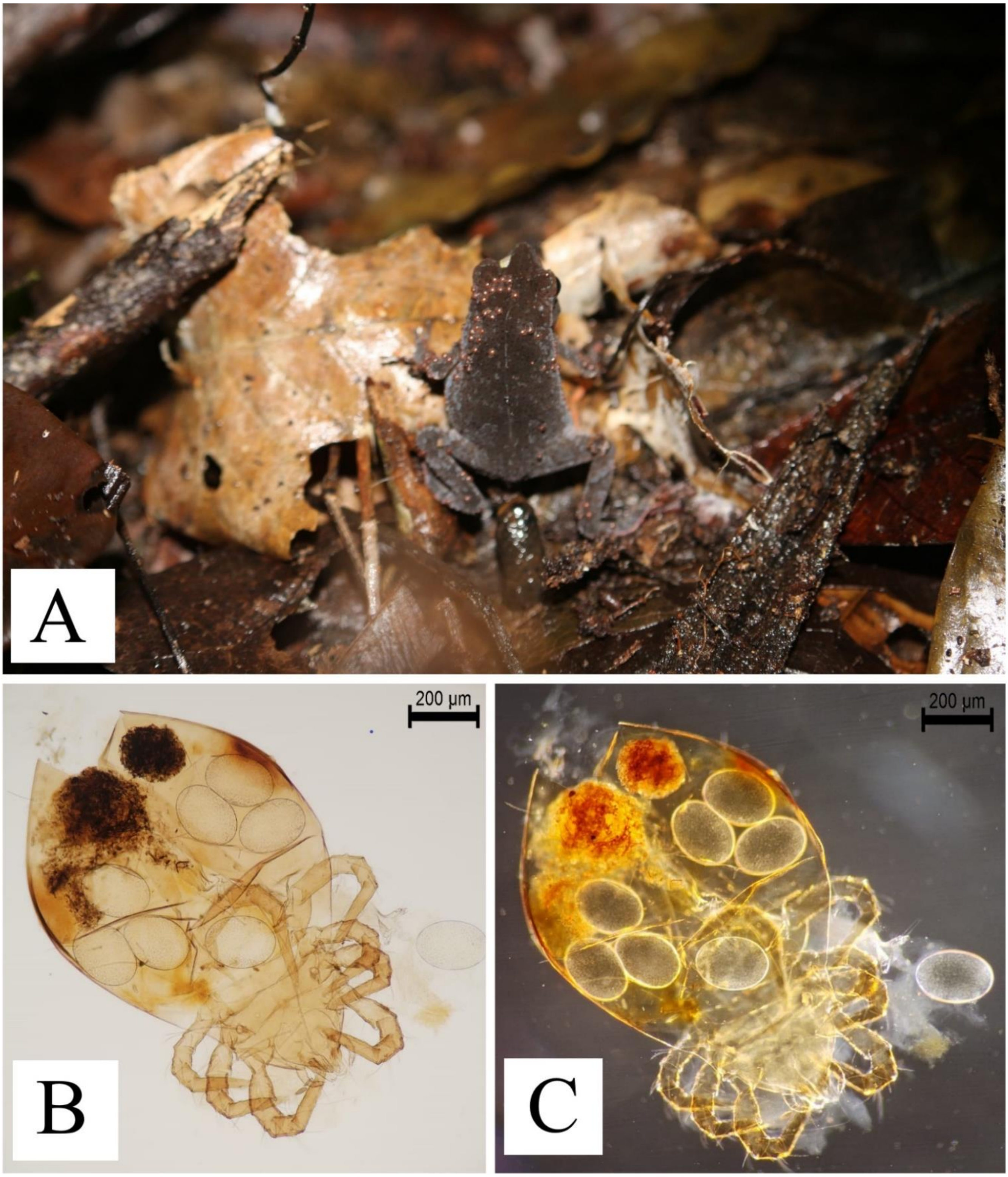


**Figure 1.** *Archegozetes magnus* (Trhypochthoniidae) on dorsum of *Rhinella alata* (Bufonidae) in leaf litter Darien National Park, Panama (**A**), a female specimen in microscope slide in light field (**B**) and dark field (**C**).

32 nymphs *ex Tityus festae* Borelli; anatomical location: mainly on the dorsum of the body, 2 individuals on carapace, 2 and 17 individuals on tergites IV and VII of mesosoma respectively, and 7 individuals in segments I and II of metasoma (Fig. 4). PANAMÁ: Darién province, Santa Fe, Quintín. 9 July 2019. Coll. Roberto Miranda, Ingrid Murgas, Juan "Largo" Lezcano, Lyska Castillo.

Immature and adult mites were identified as *A. magnus*, according to Badejo et al. (2002). In addition, we considered as valid on *bona fide* the criteria of Subías (2004, updated 2024) to the establish of *A. magnus* as the only species of the genus. Since *A. magnus* lives in humid areas, contact with its hosts must occur in this type of environment.

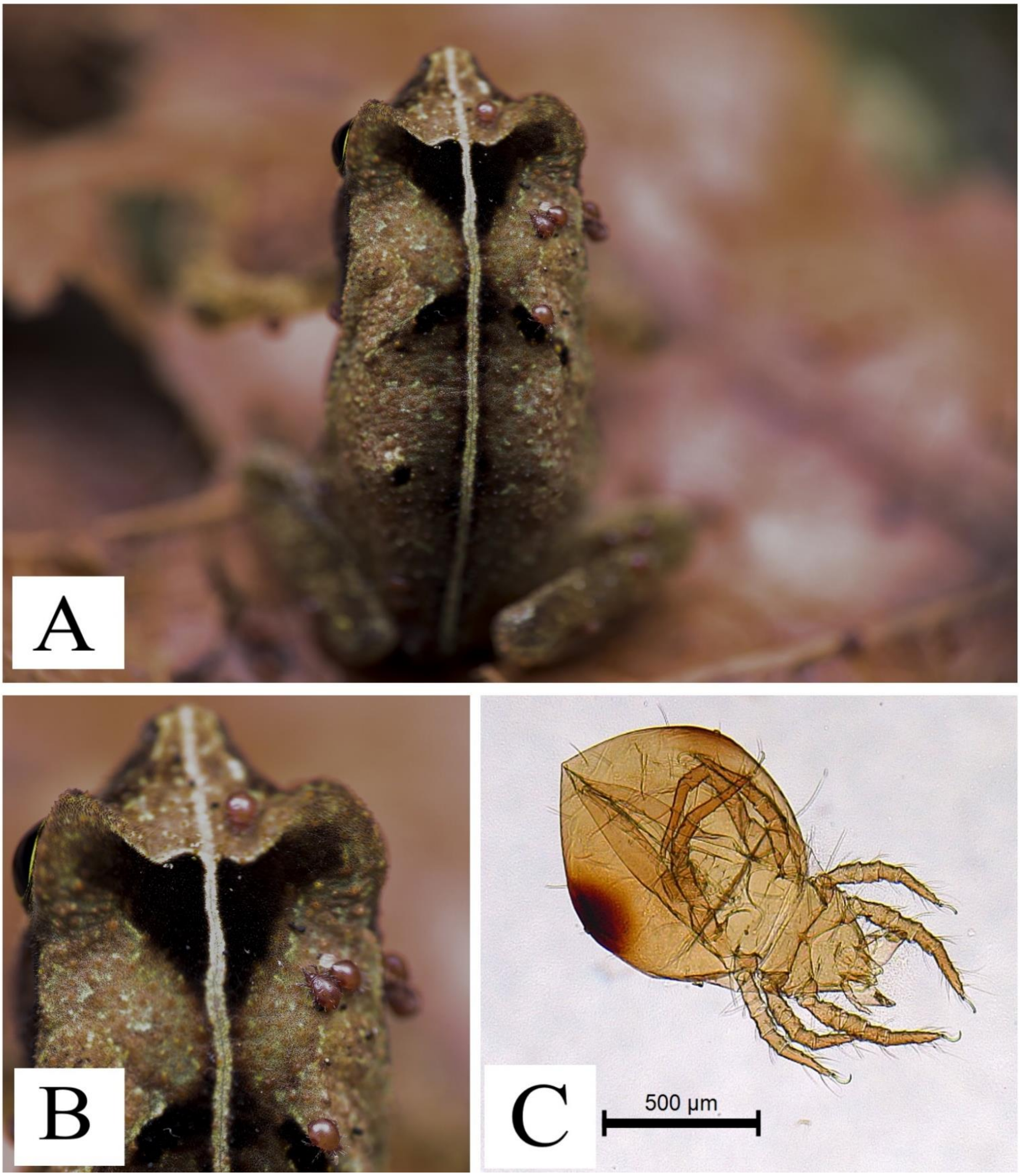


**Figure 2.** *Archegozetes magnus* on dorsum of *Rhinella alata* (Bufonidae) in leaf litter Soberanía National Park, Panama (**A**, **B**), a female specimen mounted in microscope slide (**C**).

*Archegozetes magnus* is a prolific parthenogenetic species (Badejo et al., 2002; Beaty et al., 2013), which explains the finding of females and immatures in our new phoretic association reports. In figures 1 (B, C) and 3 (B, C) the females have 8 and 20 eggs inside their body. In the case of the toad *R. alata*, this species is present in western Panama, Colombia and Ecuador (Ibáñez et al., 1999; dos Santos et al., 2015; Samudio et al., 2015). *Rhinella alata* has diurnal and terrestrial habits and is frequently observed among leaf litter, under rocks, logs or decaying wood, in places near bodies of water, or on trails used by the leaf-cutting ant *Atta colombica* (Guérin-Méneville), which they include as prey (Ibáñez et al., 1999; McElroy, 2015; Turcios-Casco, 2018). On the other hand, this species usually perches at the night on leaves at a low height (Ibáñez et al., 1999; Sosa-Bartuano, pers. obs.). Thus, the fact that both species inhabit the same type of environment, humid areas, increases the possibility of contact.

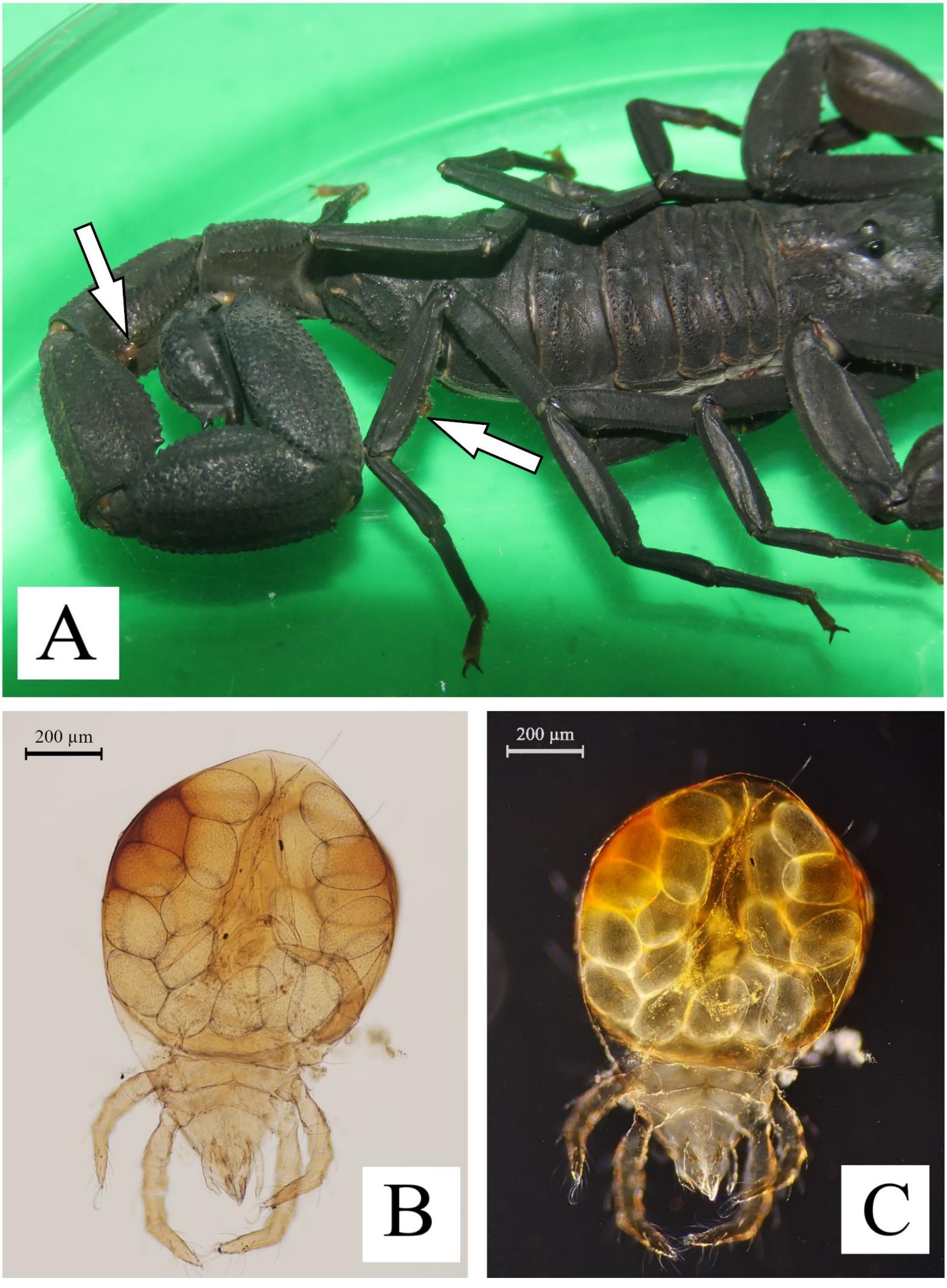


**Figure 3.** *Archegozetes magnus* on *Tityus jaimei* (Buthidae) male collected from Santa Fe National Park, Veraguas (**A**), a female specimen mounted in microscope slide in light field (**B**) and dark field (**C**).

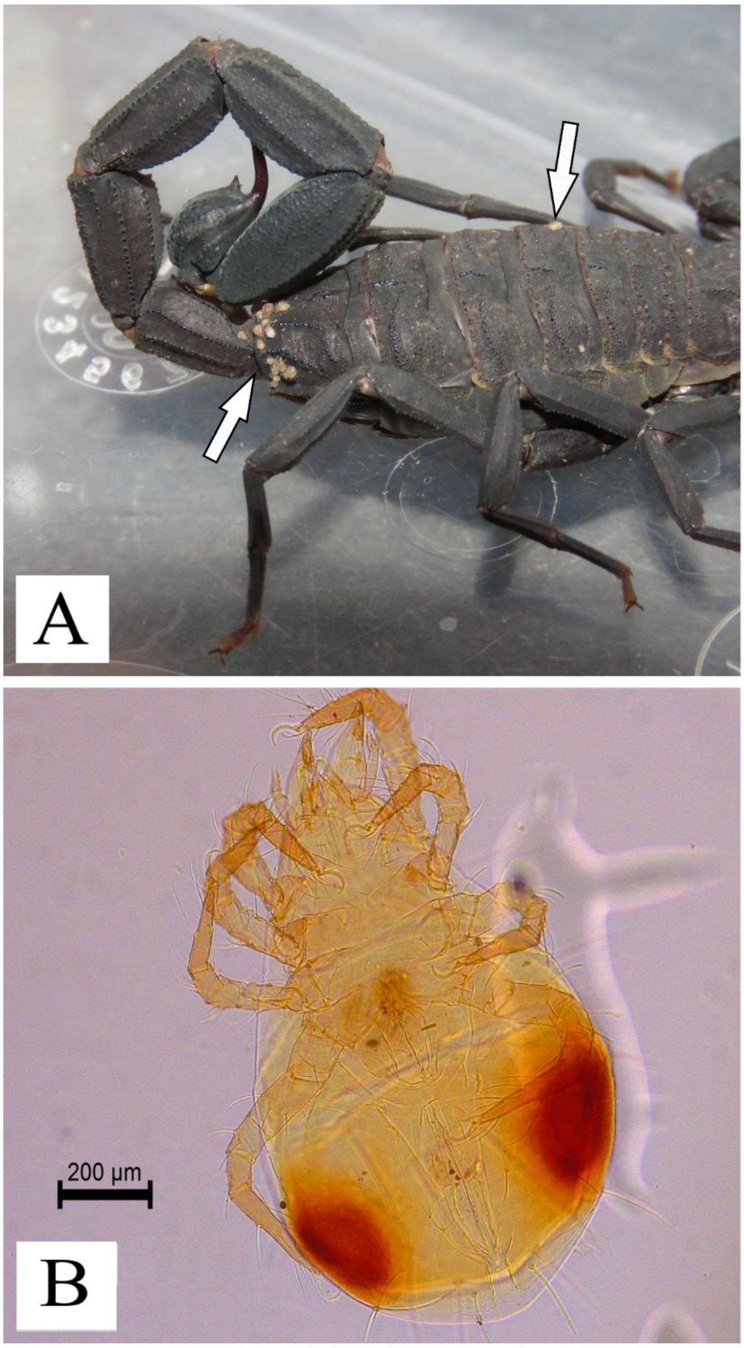


**Figure 4**. *Archegozetes magnus* on *Tityus festae* (Buthidae) female collected from Quintín, Santa Fe, Darién (**A**), a nymph specimen mounted in microscope slide (**B**).

To our knowledge, the finding of two *R. alata* in Panama correspond to the second species of amphibian as carrier of *A. magnus*, being *E. pustulosus* the first one (Beaty et al., 2013). Similar to Beaty et al. (2013), our observations are consistent with phoresis and not parasitism, which contrasts with the opinion of Mendoza-Roldan et al. (2020), who reported *A. longisetosus* mites parasitizing *R. major* Müller & Hellmich in Brazil. However, these authors did not present evidence of damage, without taking into account the evidence of mycophagous and predatory/scavenging habits previously reported for this species (Heethoff et al., 2013).

On the other hand, Salazar-Filippo et al. (2024) reported *Archegozetes* spp. as preys of *E. pustulosus* arguing that predation could occur due to the generalist behavior of this species of frog. Another report of *Archegozetes* spp. as prey of Anura includes the Dendrobatid frog *Oophaga sylvatica* (Funkhouser) (McGugan et al., 2016).

Regarding the finding of *Archegozetes* mites on the scorpions *T. jaimei* and *T. festae*, both species are considered of health importance in Panama and are mainly associated with humid forests (Borges et al., 2012). These scorpion species present vertical and horizontal displacements during their hunt and mate activities, and refuge in the bark of trees, epiphytes, palm bracts, and on the ground in fallen trunks and roots (Miranda, 2022). Considering the behavior of both species, contact must have occurred during the scorpions' passage through points with a high density of *A. magnus* or when the scorpions took refuge near the ground.

Similar to previous reports, *A. magnus* collected in both *Rhinella alata* and the two *Tityus* species were located mainly on the dorsum of the body (Townsend et al., 2008; Beaty et al., 2013; Waleckx et al., 2018) however, in toads they were mainly found in the anterior region of the body (head and forelimbs), while in scorpions they were mainly located in the posterior part of the body (meso- and metasoma).

In summary, both the natural history and taxonomy of *Archegozetes* require further research.

### Authors' contributions

**Roberto J. Miranda:** Conceptualization (equal), methodology (lead), investigation (lead), visualization (lead), writing- original draft (equal). **Ángel Sosa-Bartuano:** Methodology (supporting), investigation (supporting), data curation, writing-review & editing (equal). **Lillian Domínguez:** Data curation, visualization (supporting), writing-review & editing (equal). **Samuel Sucre:** Methodology (supporting), data curation, writing-review & editing (equal). **Macario González-Pinzón:** Methodology (supporting), visualization (supporting), writing-review & editing (equal). **Sergio Bermúdez:** Conceptualization (equal), investigation (supporting), writing- original draft (equal).

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Not applicable.

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### Conflict of interest

We declare that we have no conflicts of interest.

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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
**Zoobank:** https://zoobank.org/A2B41650-74DF-4517-8B0A-3F00C9B097B8

## 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* |
| Artvin | Mesostigmata | Ixodorhynchidae | *Hemilaelaps farrieri* | Squamata: *Dolichophis caspius* |
| Artvin | Mesostigmata | Macronyssidae | *Ophionyssus natricis* | Squamata: *Natrix tessellata* |
| Artvin | Mesostigmata | Macronyssidae | *Ophionyssus saurarum* | Sauria: *Darevskia adjarica*, *D. derjugini*, and *D. obscura* |
| Artvin | Prostigmata | Pterygosomatidae | *Geckobia turkestana* | Sauria: *Mediodactylus* cf. *kotschyi* |
| Artvin | Prostigmata | Trombiculidae | *Lacertacarus callosus* | Sauria: *Darevskia adjarica*, *D. clarkorum*, *D. derjugini*, and *D. obscura* |
| Artvin | Prostigmata | Trombiculidae | *Lacertacarus similis* | Sauria: *Darevskia adjarica*, *D. clarkorum*, *D. derjugini*, and *D. obscura* |
| Artvin | Prostigmata | Trombiculidae | *Odontacarus efferus* | Sauria: *D. adjarica*, *D. derjugini*, *and D. obscura* Squamata: *Coronella austriaca*, *Platyceps najadum*, *Telescopus fallax*, and *Zamenis longissimus* |
| Artvin | Prostigmata | Trombiculidae | *Odontacarus hushchai* | Sauria: *Darevskia adjarica*, *D. clarkorum*, and *D. obscura* |
| Artvin | Prostigmata | Trombiculidae | *Odontacarus naumovi* | Sauria: *Darevskia adjarica*, *D. clarkorum*, and *D. obscura* |
| Artvin | Prostigmata | Trombiculidae | *Odontacarus saxicolis* | Sauria: *Darevskia adjarica*, *D. clarkorum*, and *D. obscura* |
| Sakarya | Ixodida | Ixodidae | *Hyalomma aegyptium* | Sauria: *Podarcis tauricus* Testudinata: *Testudo graeca* |
| Sakarya | Ixodida | Ixodidae | *Ixodes ricinus* | Sauria: *Darevskia bithynica*, *Podarcis muralis*, and *Lacerta viridis* |
| Sakarya | 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*<br>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*<br>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*<br>Leptotyphlopidae: *Myriopholis macrorhyncha*<br>Scincidae: *Eumeces* (*E.*) *schneideri* and *Trachylepis aurata*<br>Varanidae: *Varanus griseus* | Hoogstraal, 1959; Keskin et al., 2013 |
| | *Haemaphysalis* sp. | Agamidae: *S. stellio*<br>Lacertidae: *L. trilineata* | Aydın et al., 2002 |
| ***Hyalomma*** | *H. aegyptium* | Lacertidae: *Acanthodactylus schreiberi*, *A. cappadocica,* and *D. valentini*<br>Scincidae: *Trachylepis vittata*<br>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*<br>Lacertidae: *L. trilineata* and *L. viridis* | Aydın et al., 2002 |
| ***Rhipicephalus*** | *R. annulatus* | Lacertidae: *A. cappadocica*<br>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*<br>Gekkonidae: *Mediodactylus heterocercum*<br>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*<br>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*<br>Gekkonidae: *Hemidactylus turcicus*<br>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*<br>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*<br>Scincidae: *Ablepharus chernovi* and *Eumeces schneiderii* | Jabbarpour, 2016 |
| | *Ophionyssus* sp. | Gekkonidae: *Hemidactylus turcicus* and *Stenodactylus grandiceps*<br>Lacertidae: *Apathya cappadocica, D.dryada, L. viridis, O. elegans, Parvilacerta parva, Phoenicolacerta laevis,* and *Podarcis muralis* | Jabbarpour, 2016 |

| | | | |
|---|---|---|---|
| Pterygosomatidae | *Geckobia tarantula* | Gekkonidae: *Hemidactylus turcicus*<br>Lacertidae: *Apathya cappadocica* | Jabbarpour, 2016 |
| | *Geckobia turkestana* | Gekkonidae: *Asaccus barani, Cyrtopodion scabrum,* and *Hemidactylus turcicus*<br>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*<br>Lacertidae: *Apathya cappadocica* | |
| Tetranychidae | *Petrobia latens* | Lacertidae: *Darevskia armeniaca* | Jabbarpour, 2016 |
| Trombiculidae | *Lacertacarus callosus* | Gekkonidae: *Stenodactylus grandiceps*<br>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*<br>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*<br>Scincidae: *Eumeces schneiderii* | |
| | *Lacertacarus turcicus* | Lacertidae: *Lacerta* spp. | Kalúz, 2011 |
| | *Matacarus demrei* | Eublepharidae: *Eublepharis angramainyu*<br>Gekkonidae: *Asaccus barani*<br>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*<br>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

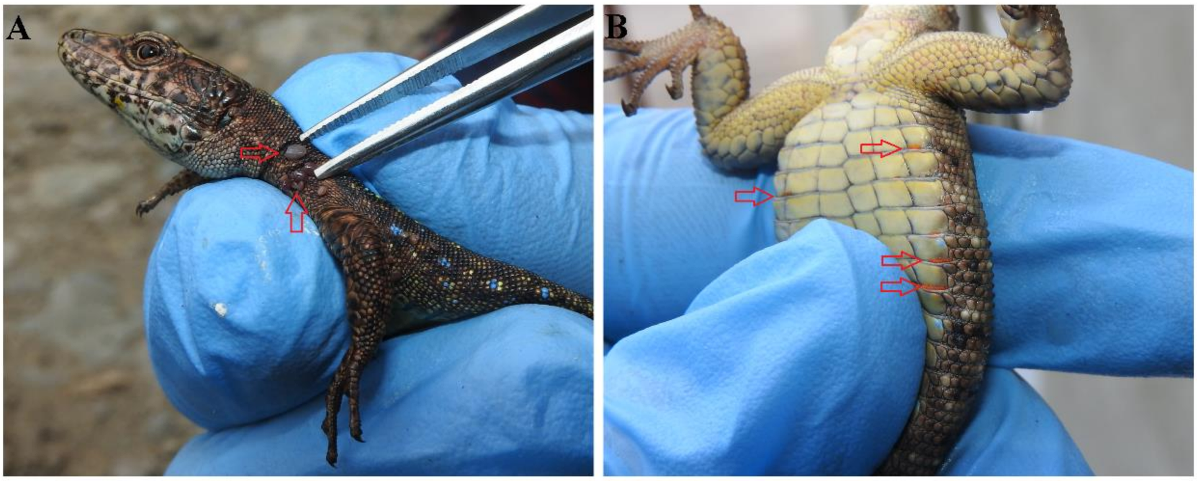

**Figure 1.** Ectoparasite infestation on hosts: **A.** *Darevskia obscura* (from Borçka, Artvin), **B.** *Darevskia clarkorum* (from Borçka, Artvin) (red arrows: mite specimens on the right, and ticks in the larval and nymph stages on the left).

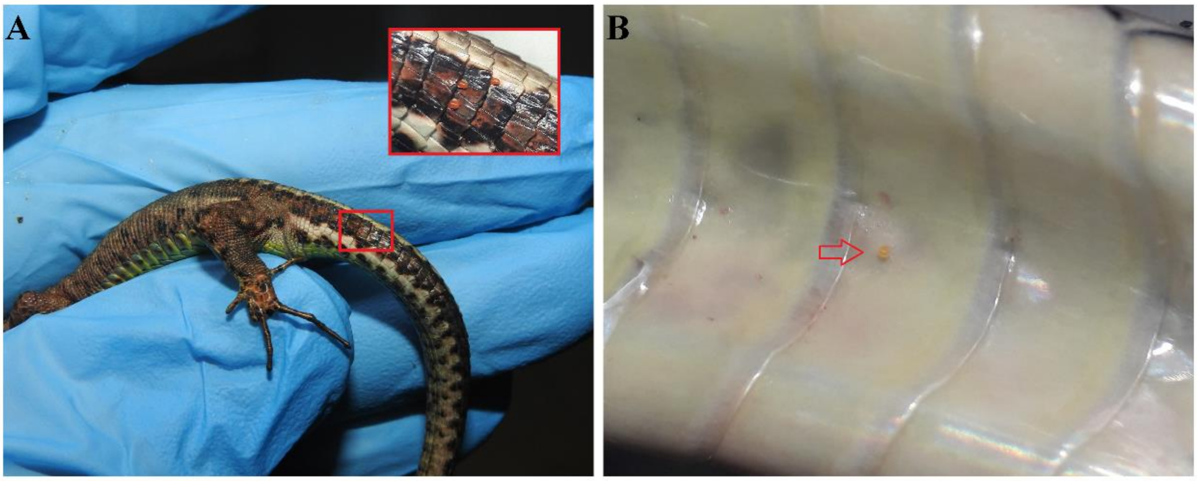

**Figure 2.** Ectoparasite infestation on hosts: **A.** *Darevskia derjugini* (from Borçka, Artvin), **B.** *Platyceps najadum* (from Borçka, Artvin) (red rectangles and arrow: trombiculid specimens).

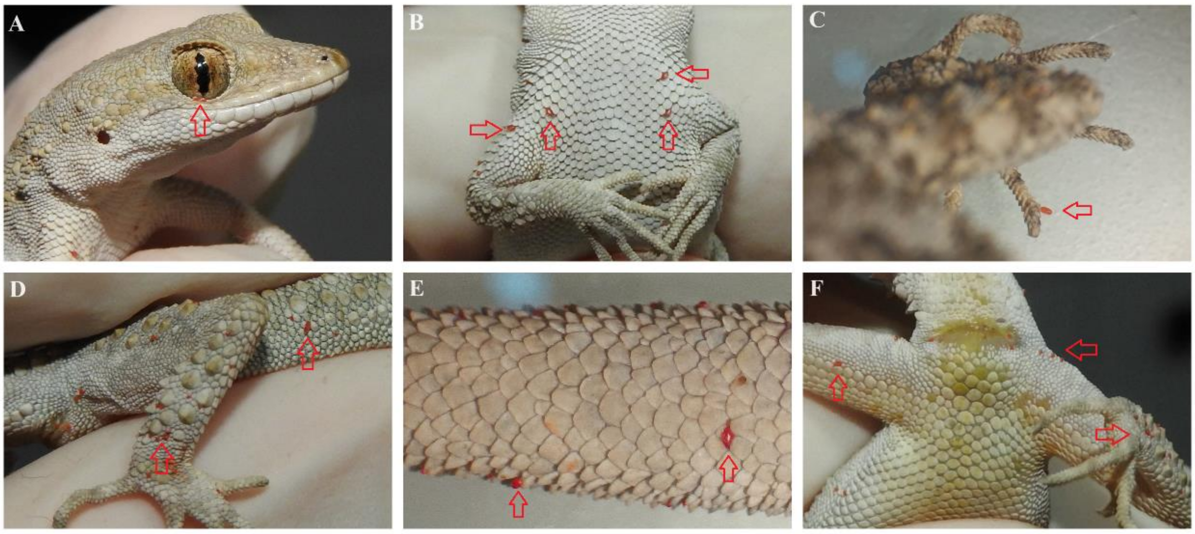

**Figure 3.** *Geckobia turkestana* (red arrows) on the Kotschy`s Gecko (*Mediodactylus* cf. *kotschyi*) (from Ardanuç, Artvin).

**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).

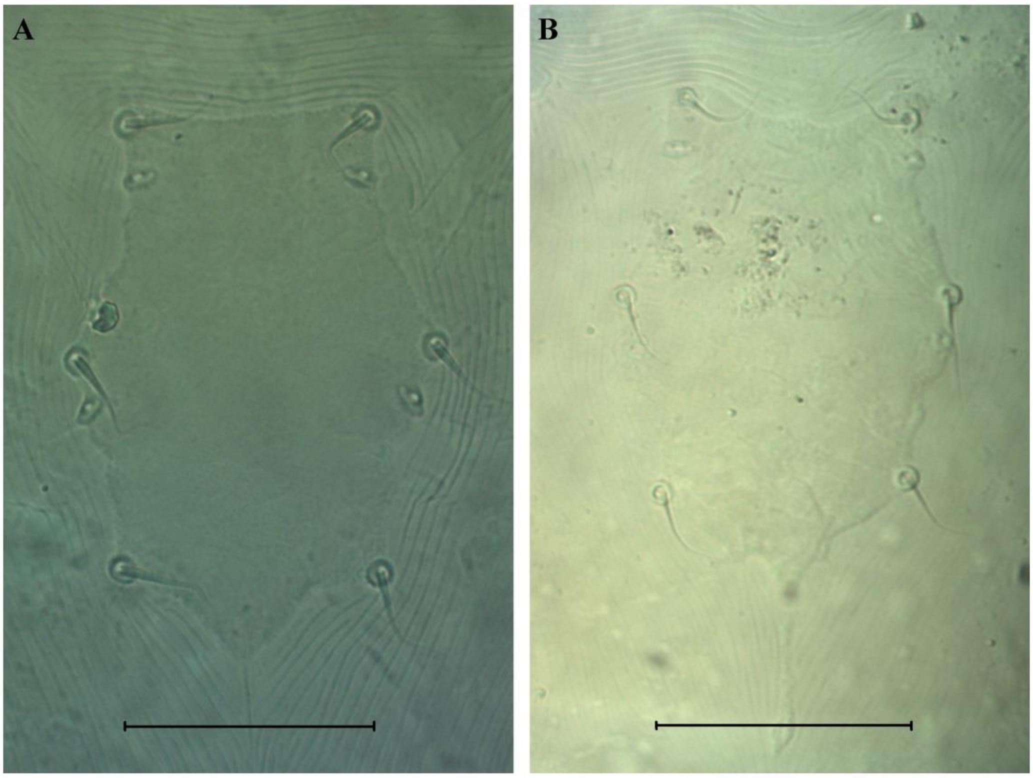


**Figure 8. A**. Sternal shields: **A.** *Ophionyssus natricis* (protonymph), **B.** *Op. saurarum* (protonymph) (scale bars: 50 µm).

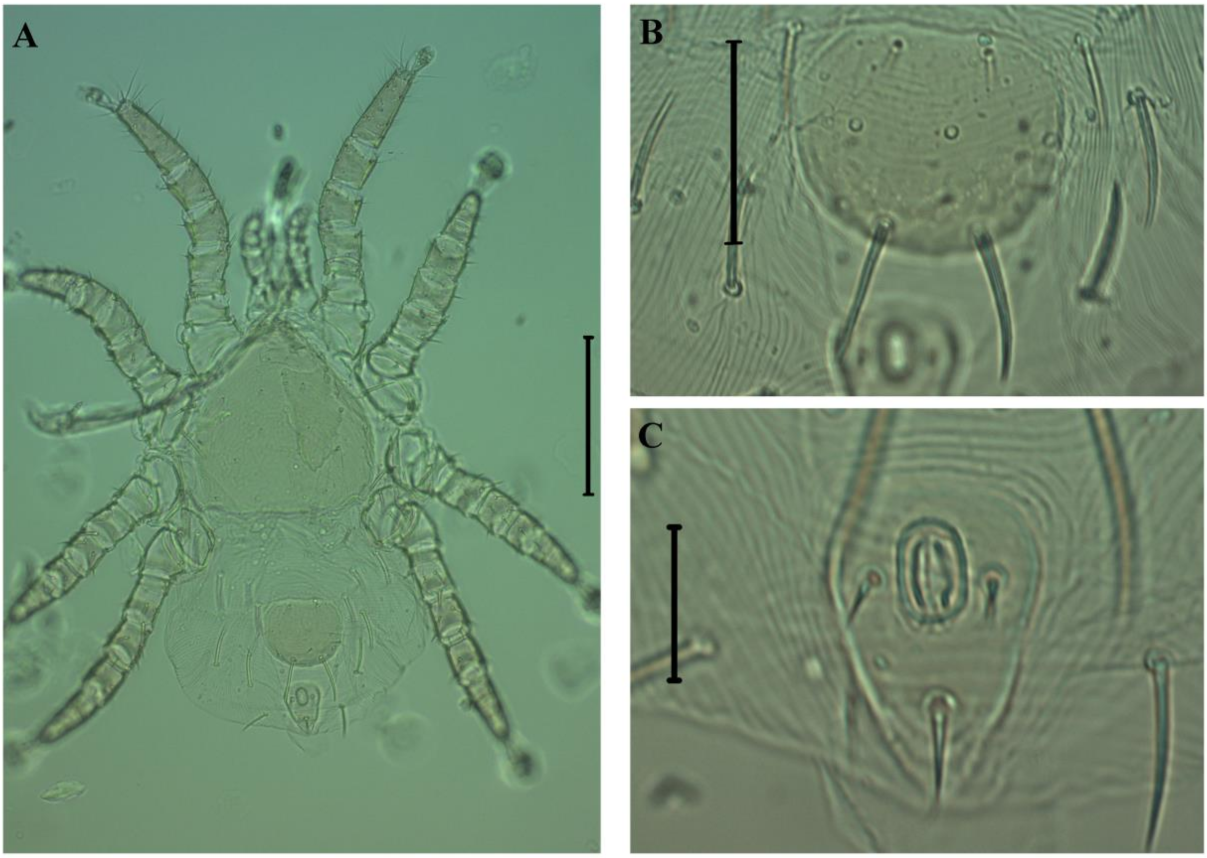


**Figure 9.** *Ophionyssus saurarum* (protonymph): **A.** Dorsal view (scale bar: 250 µm), **B.** Pygidial plate (scale bar: 50 µm), **C.** Anus (scale bar: 25 µm).

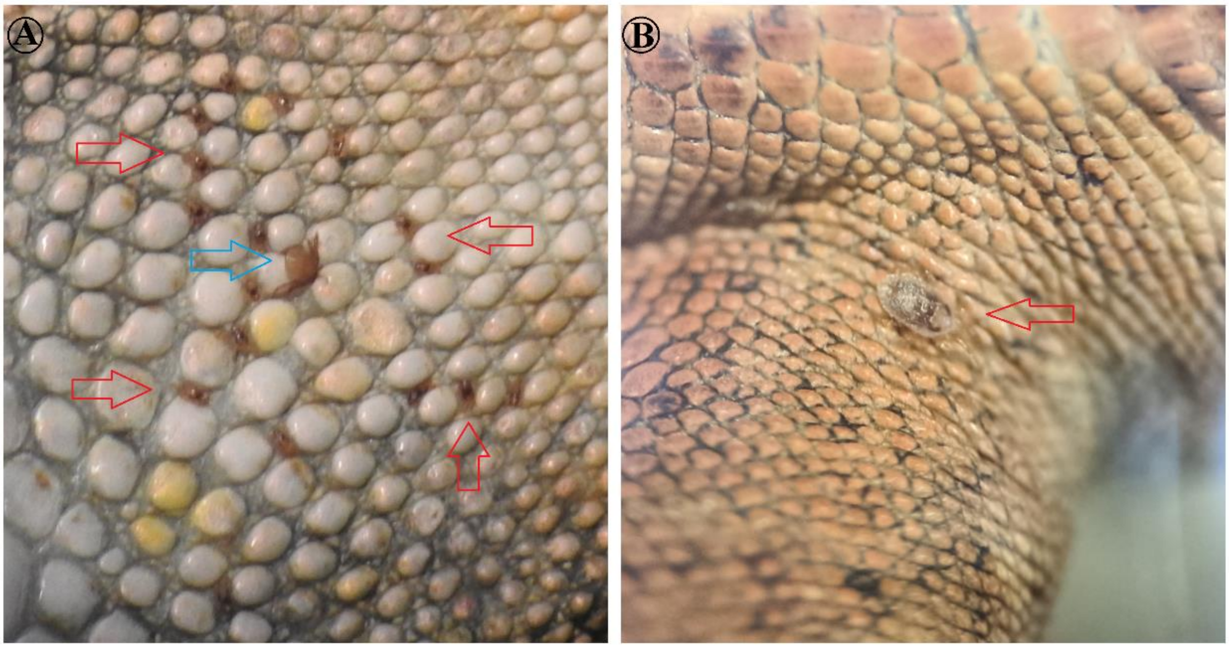


**Figure 10. A.** Protonymph specimens of *Ophionyssus saurarum* on the spiny-tailed lizard (*Darevskia obscura*), **B.** The same specimens on the green lizard (*Lacerta viridis*) (red arrows: mite specimens; blue arrow: ticks in the larval stage).

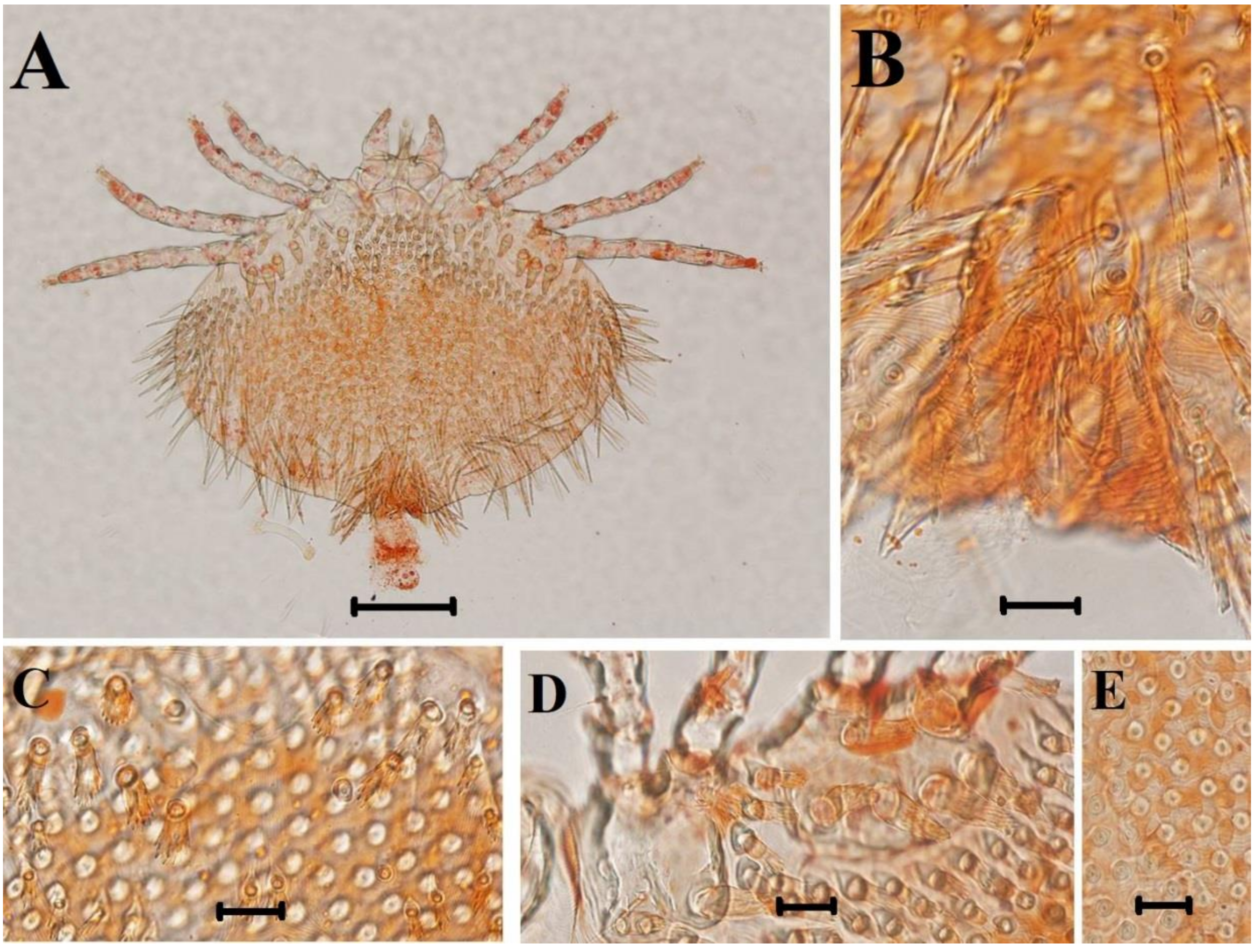


**Figure 11.** *Geckobia turkestana* (♀): **A.** Dorsal view (scale bar: 100 µm), **B.** Genital region (scale bar: 100 µm), **C.** Scutum (scale bar: 100 µm), **D.** Coxae I-IV (scale bar: 100 µm), **E.** Ventral setae (scale bar: 50 µm).


**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*).

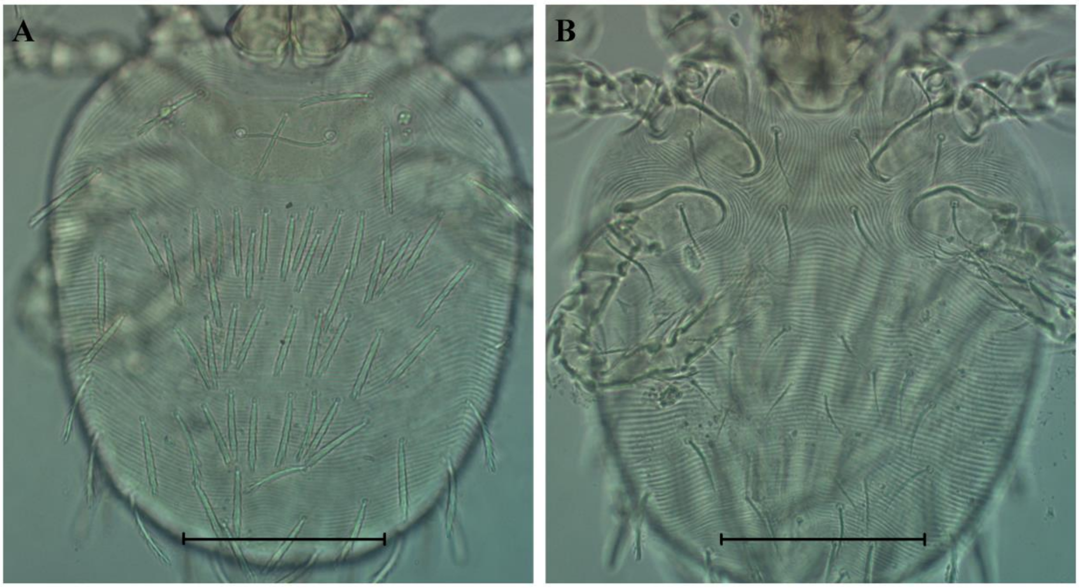


**Figure 13.** *Lacertacarus callosus* (larva): **A.** Dorsal view of idiosoma, **B.** Ventral view of idiosoma (scale bars: 100 µm).

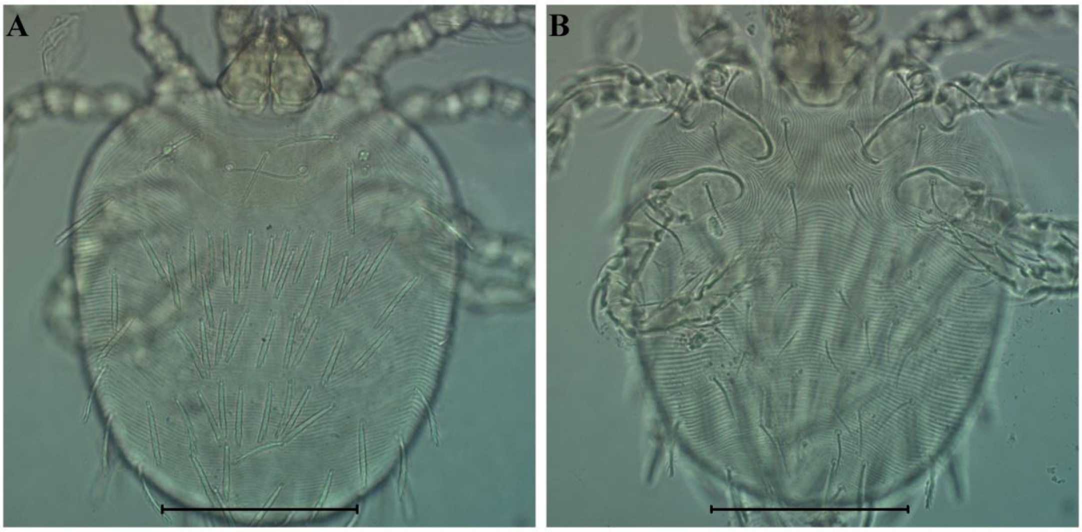


**Figure 14.** *Lacertacarus similis* (larva): **A.** Dorsal view of idiosoma, **B.** Ventral view of idiosoma (scale bars: 100 µm).

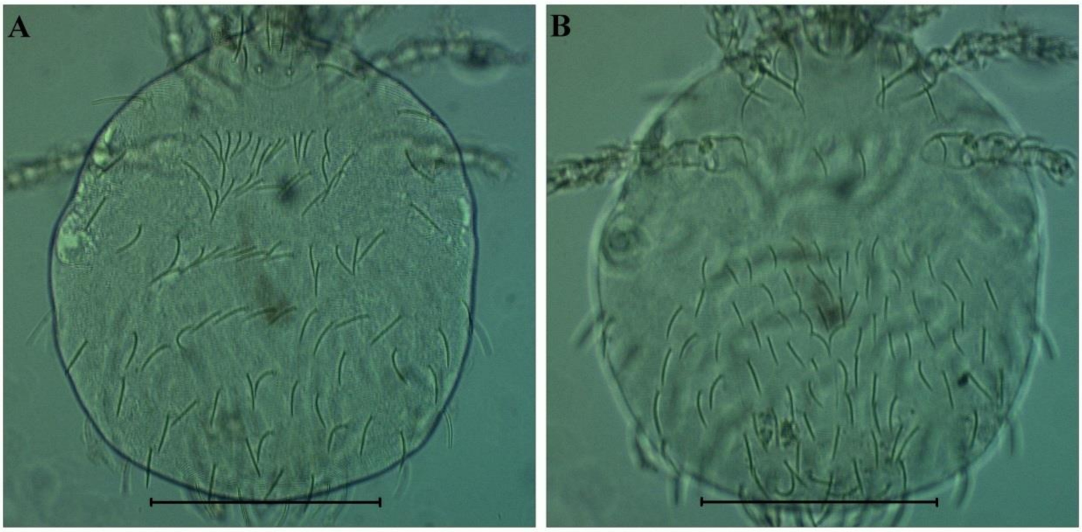


**Figure 15.** *Odontacarus efferus* (larva): **A.** Dorsal view of idiosoma, **B.** Ventral view of idiosoma (scale bars: 250 µm).

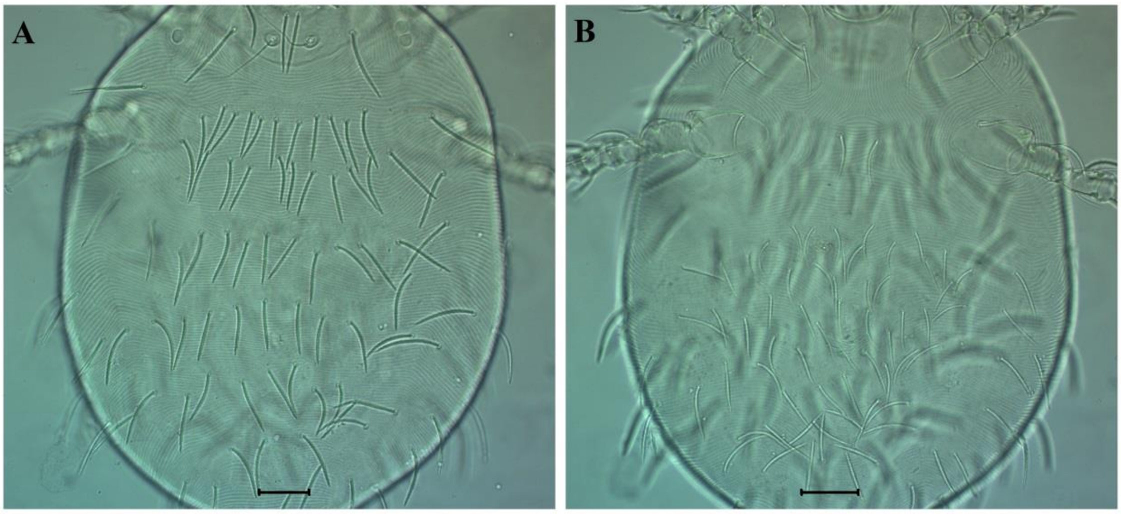


**Figure 16.** *Odontacarus hushchai* (larva): **A.** Dorsal view of idiosoma, **B.** Ventral view of idiosoma (scale bars: 250 µm).

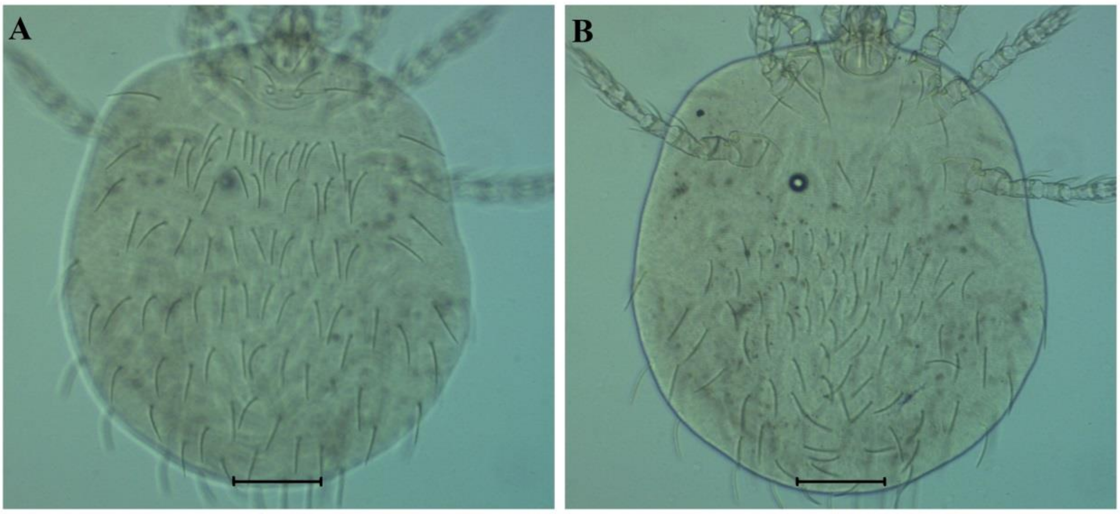


**Figure 17.** *Odontacarus naumovi* (larva): **A.** Dorsal view of idiosoma, **B.** Ventral view idiosoma (scale bars: 250 µm).

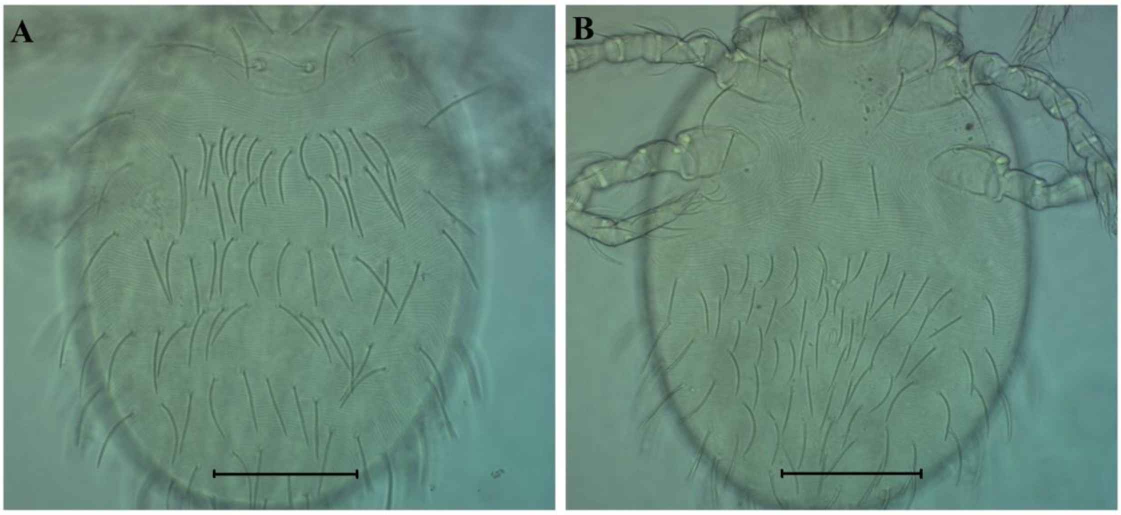


**Figure 18.** *Odontacarus saxicolis* (larva): **A.** Dorsal view of idiosoma, **B.** Ventral view of idiosoma (scale bars: 250 µm).

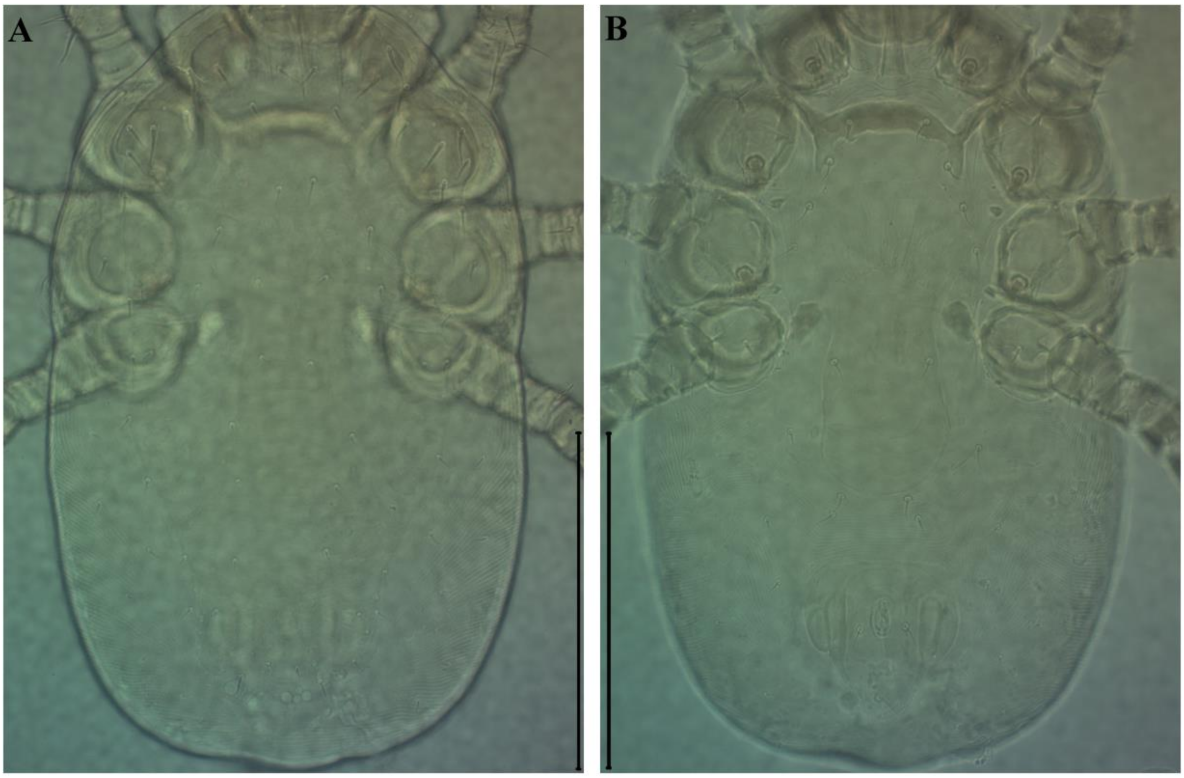

**Figure 19.** *Hemilaelaps farrieri*: **A.** Dorsal view of idiosoma, **B.** Ventral view of idiosoma (scale bar: 250 μm).

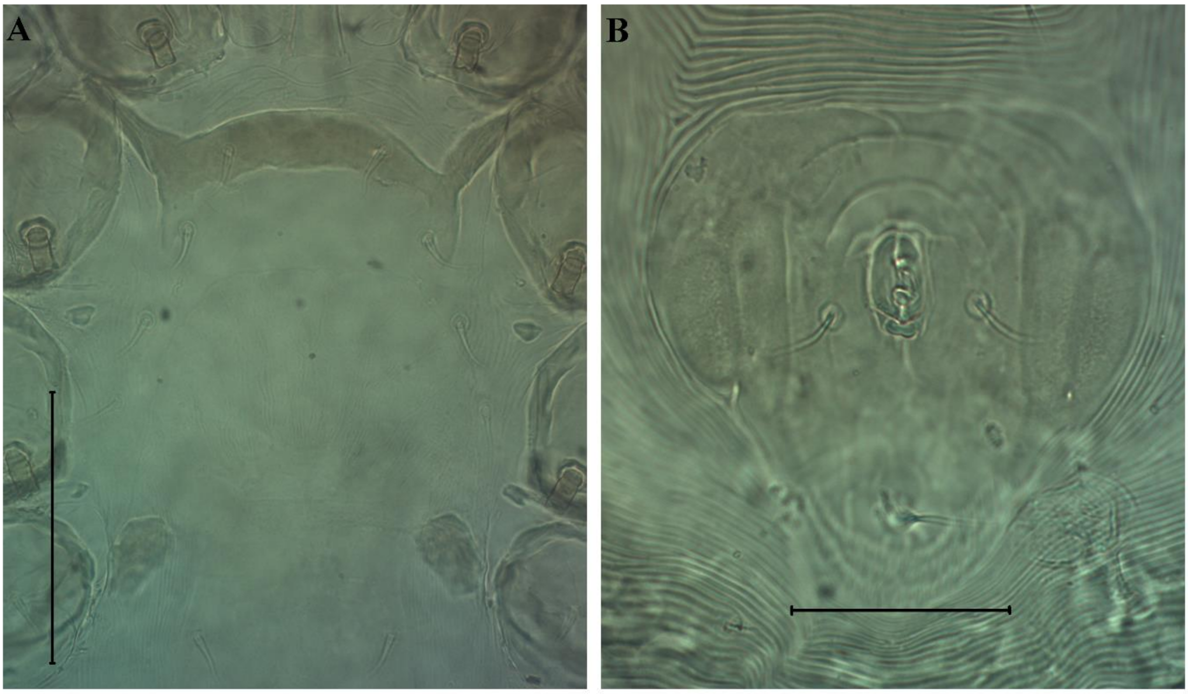

**Figure 20. A.** *Hemilaelaps farrieri*: **A.** Dorsal view of idiosoma (scale bar: 100 μm) **B.** Anus (scale bar: 50 μm).

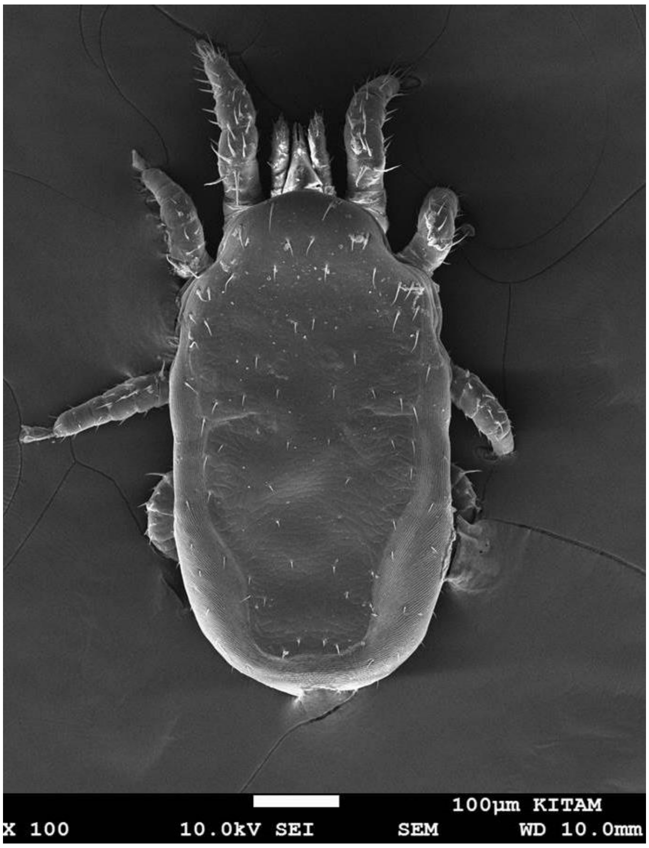


**Figure 21.** SEM image of *Hemilelaps farrieri* (♀): dorsal view.

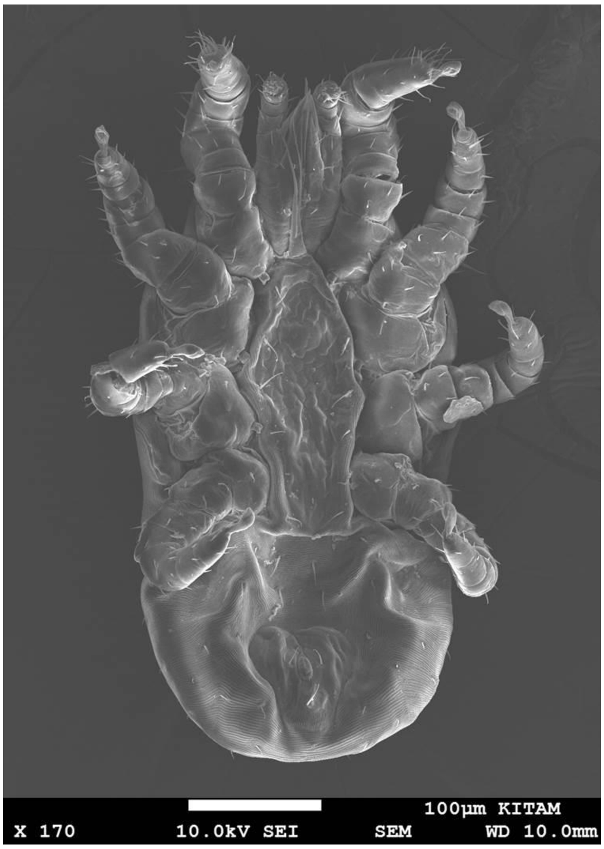


**Figure 22**. SEM image of *Hemilelaps farrieri* (♀): ventral view.

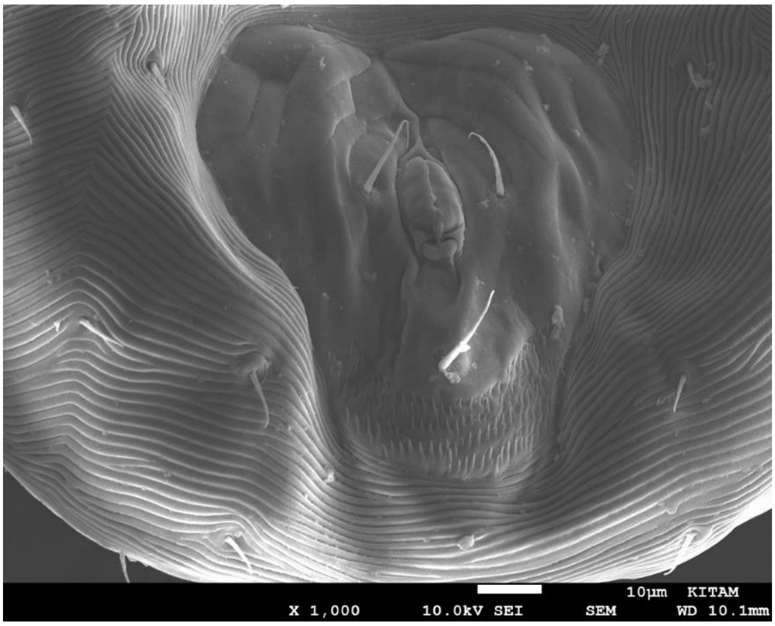


**Figure 23**. SEM image of *Hemilaelaps farrieri* (♀): anal plate.

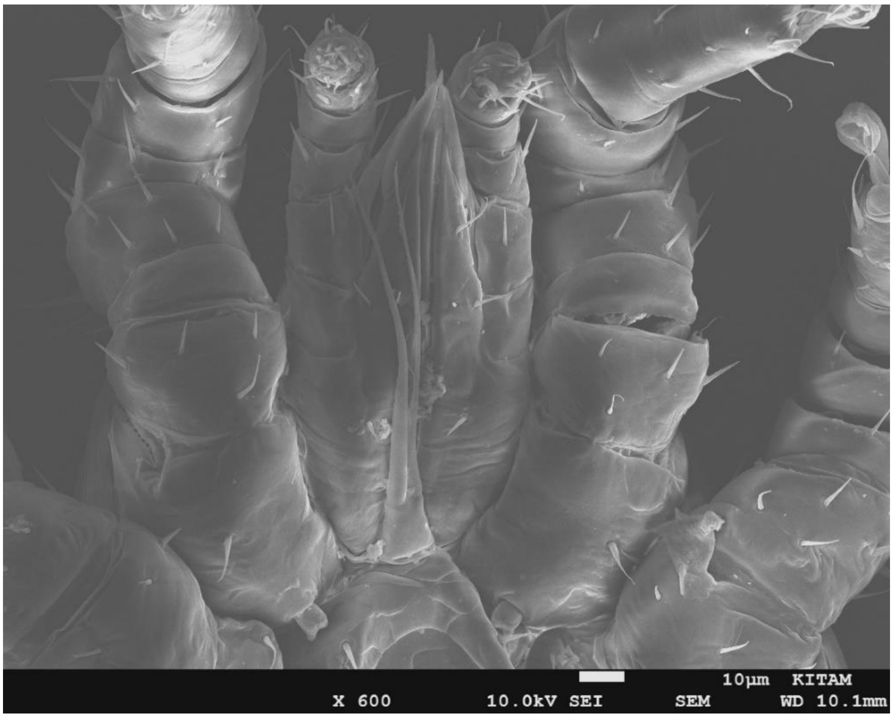


**Figure 24**. SEM image of *Hemilaelaps farrieri* (♀): tritosternum.

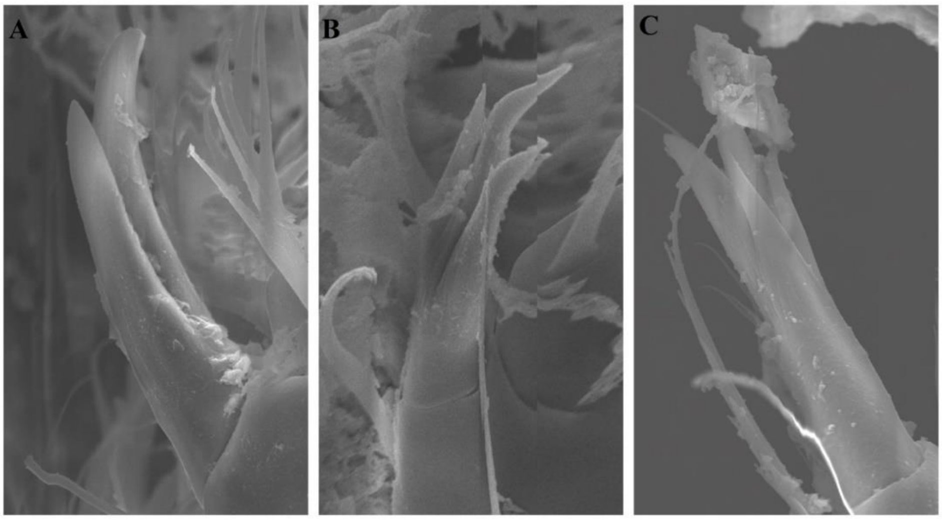


**Figure 25.** SEM image of *Odontacarus* palpal claw numbers: **A.** *O. efferus*, **B.** *O. naumovi*, **C.** *O. hushchai*.

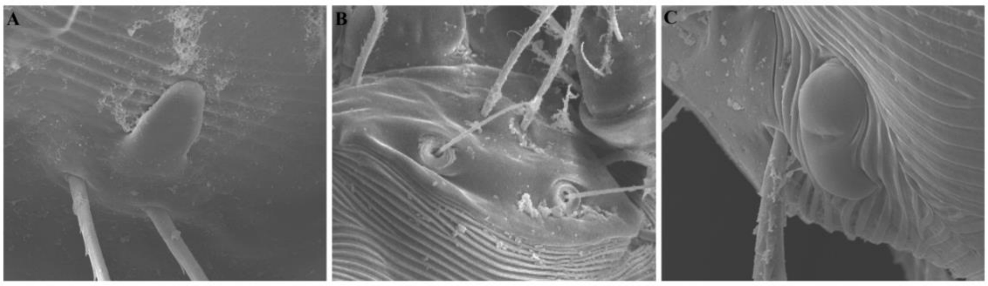


**Figure 26.** SEM images of nasus, scutum, and eye structures of *Odontacarus naumovi.*

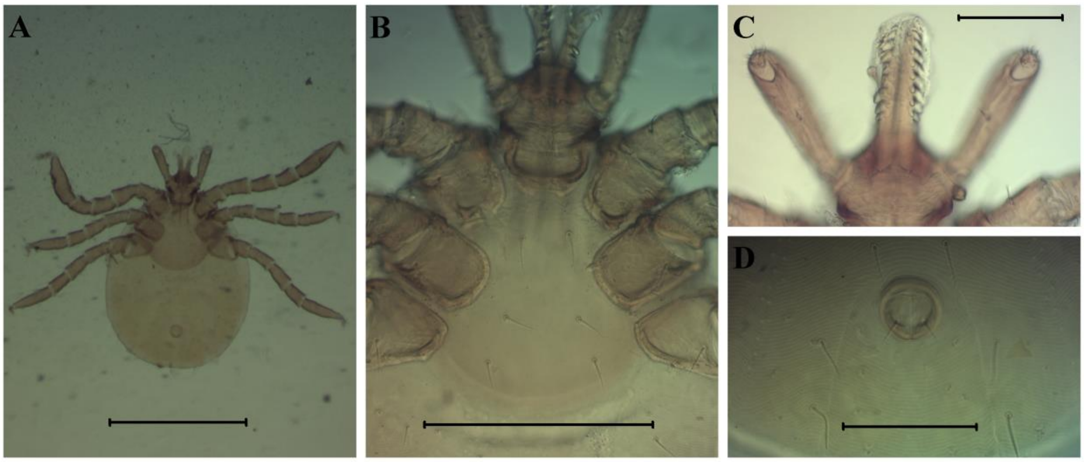


**Figure 27. A.** *Ixodes ricinus* larva (scale bar: 500 µm), **B.** Coxae I-III and basis caputili (scale bar: 250 µm), **C.** Hypostome (scale bar: 100 µm), **D.** Anal groove (scale bar: 100 µm).

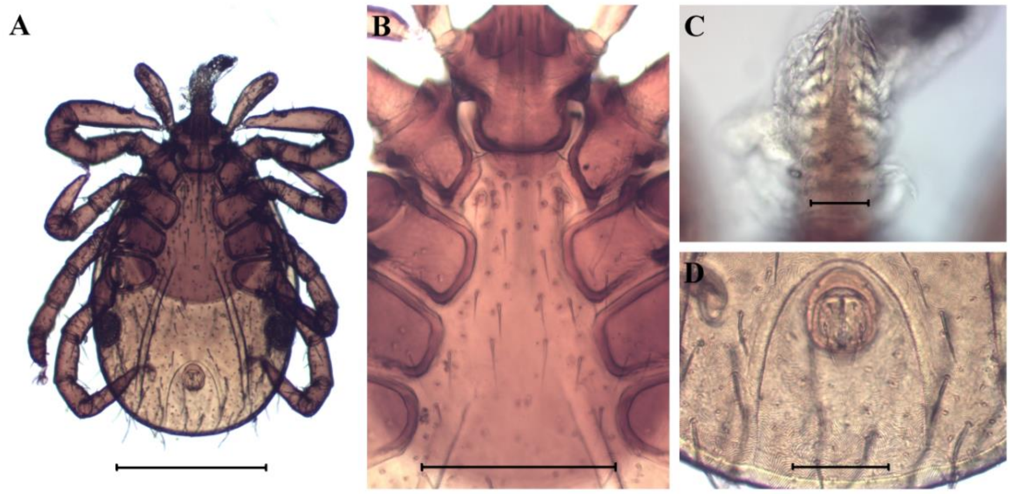


**Figure 28. A.** *Ixodes ricinus* nymph (scale bar: 1000 µm), **B.** Coxae I-III and basis caputuli (scale bar: 250 µm), **C.** Hypostome (scale bar: 100 µm), **D.** Anal groove (scale bar: 100 µm).

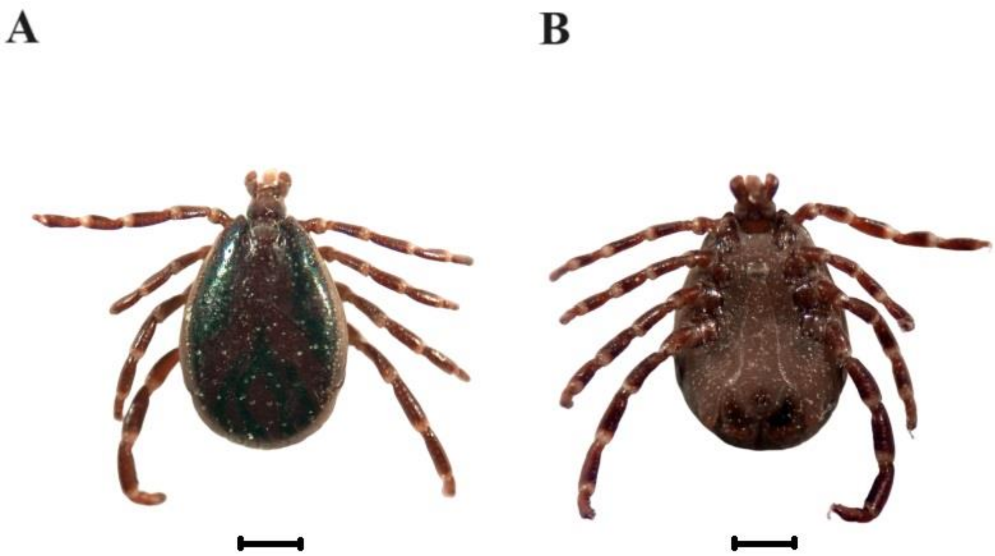


**Figure 29.** *Hyalomma aegyptium* (♂): **A.** Dorsal, **B.** Ventral (scale bars: 1 mm).

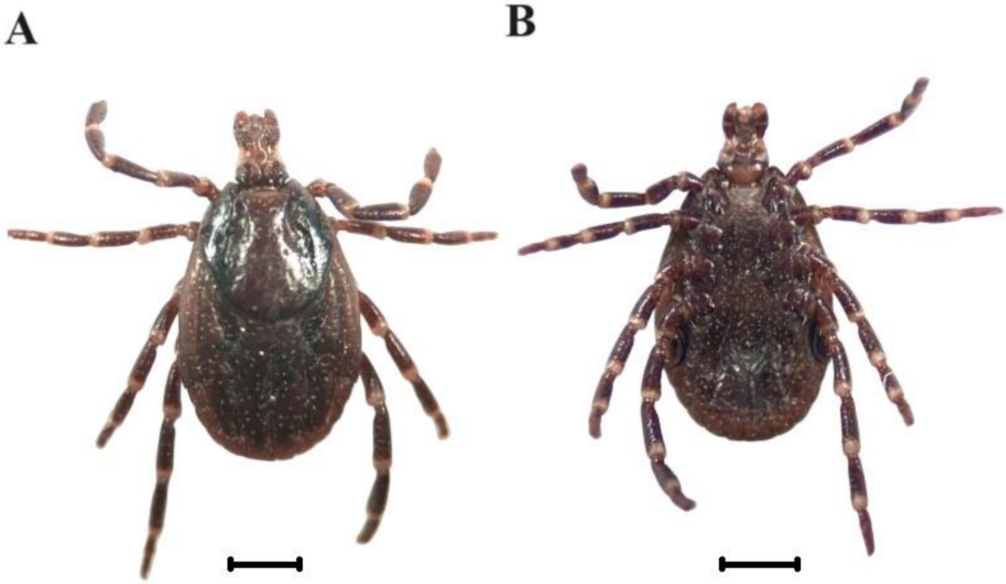


**Figure 30.** *Hyalomma aegyptium* (♀): **A.** Dorsal, **B.** Ventral (scale bars: 1 mm).

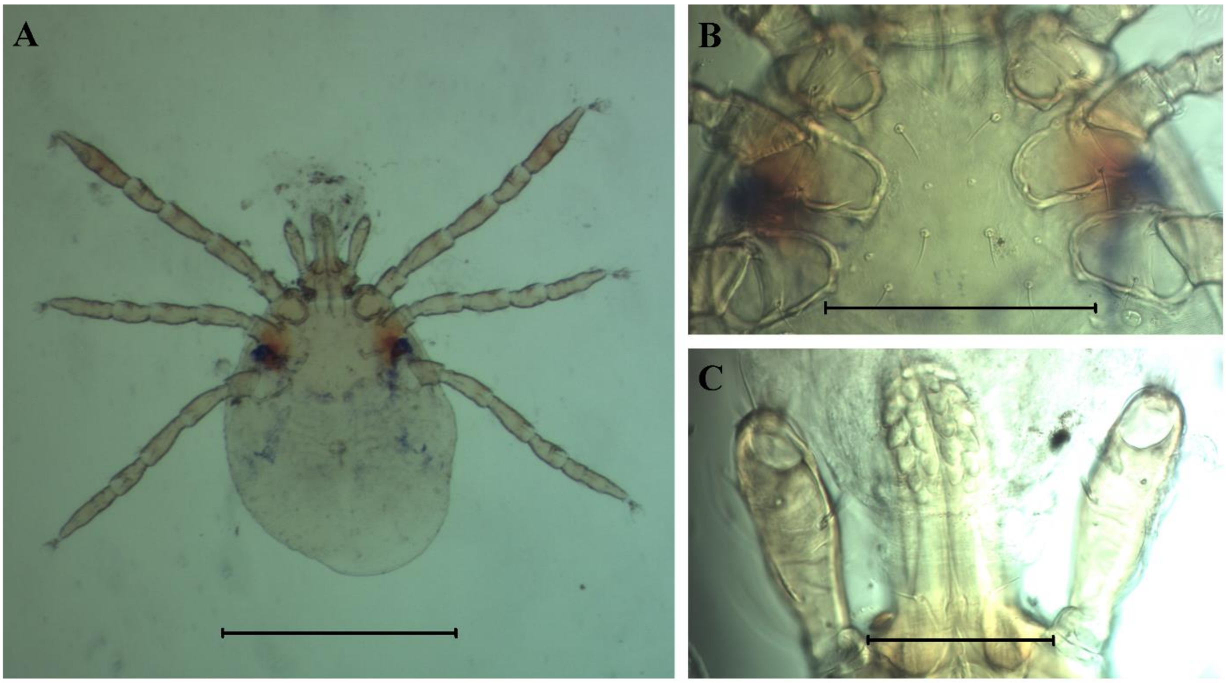


**Figure 31. A.** *Hyalomma aegyptium* larva (scale bar: 500 µm), **B.** Coxae I-III (scale bar: 250 µm) and **C.** Hypostome, (scale bar: 100 µm) collected from the Balkan wall lizard (*Podarcis tauricus*).

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RESEARCH ARTICLE

# Taxonomic investigations into carabodid mites (Acari, Oribatida, Carabodidae) of the Harşit Valley, Türkiye

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**ASBTRACT:** Oribatid mites are a dominant and biodiversity-rich group of arthropods that primarily inhabit the soil-litter system. In order to contribute to the studies on oribatid mites in Türkiye, the species belonging to the family Carabodidae of oribatid mites extracted from the soil, litter, moss, lichen, and bark collected from the Harşit valley between 2013-2015 were evaluated taxonomically. As a result of the investigations *Carabodes* (*C.*) *labyrinthicus* (Michael), *Carabodes* (*C.*) *pirinensis* Kunst, *Carabodes* (*C.*) *rugosior* Berlese, *Carabodes* (*Flexa*) *dubius* Kulijev and *Carabodes* (*Klapperiches*) *willmanni* Bernini taxa were determined. Of these, *C. willmanni* was identified as a new record for the fauna of Türkiye. The distinguishing features of the identified species were given together with scanning electron microscope photographs. Identified taxa were discussed with previously known ones based on morphological characters, and their geographical distributions are given.

**Keywords:** Distribution, fauna, new record, oribatid mites, taxonomy
**Zoobank:** https://zoobank.org/C3A4678B-E182-4092-9FFF-E828004C7241

## INTRODUCTION

Oribatid mites constitute one of the arthropod groups that predominate in the organic layers of most soils in the terrestrial environment (Norton, 1990; Norton and Behan-Pelletier, 2009). The body is well sclerotized in adults except in some primitive oribatid mites. They range in size from about 150 to 1500 µm in length. Although they mostly live in the terrestrial environment, a few species live in the aquatic environment and feed on algae, fungi, or decaying materials. Among the soil mites, oribatid mites constitute a rich group of 11628 species belonging to 166 families known and distributed in all zoogeographic regions (Subías, 2004).

The family Carabodidae Koch, which has a cosmopolitan distribution among the known families of oribatid mites, is represented by 35 genera, 18 subgenera, 385 species, and five subspecies worldwide (Subías, 2004). Eight known genera (*Austrocarabodes*, *Bathocepheus*, *Bunabodes*, *Carabodes*, *Cavernocarabodes*, *Gibbicepheus*, *Meriocepheus*, and *Odontocepheus*) are distributed in the Palearctic region, including Türkiye. As a result of the limited number of studies collected and evaluated from various habitats in our country, nine taxa belonging to the genera *Austrocarabodes* and *Carabodes* were recorded from Erzurum, Kayseri, Kastamonu, Mersin, Aksaray, Bolu and Artvin provinces (Ayyıldız, 1988; Per and Ayyıldız, 2005; Yalçın et al., 2013; Murvanidze et al., 2020; Toluk and Ayyıldız, 2021). In our country, which we think is rich in biodiversity, we believe there may be more carabodid taxa than the known ones with more studies and habitat diversity. The aim of this study, based on the material collected from the Harşit Valley, is to identify carabodid mites and to contribute to the oribatid mite fauna of Türkiye.

## MATERIALS AND METHODS

### *Description of the research area*

The Harşit Valley (Türkiye) is a region formed by the Harşit Stream, which originates from the Vauk Mountain on the eastern border of Gümüşhane. The stream feeds from the Kalkanlı and Gümüşhane Mountains and flows into the Black Sea in Tirebolu (Fig. 1). This valley has a continental and humid-temperate climate (Ağcakaya and Ayyıldız, 2020).

### *Collection, extraction, and preparation of carabodid mite specimens*

The carabodid mites were evaluated and selected from mite specimens collected between 2013 and 2015 during a faunal study (Project № 113Z094) on the raphignathoid and trombidioid mites of the Harşit Valley. Previously used methods were followed in mite collection, extraction, and preparation (Ağcakaya and Ayyıldız, 2020). Identification of carabodid mites was made using various literature and samples in our collection (Kunst, 1961; Bernini, 1975; Kulijev, 1977; Ayyıldız, 1988; Per and Ayyıldız, 2005; Weigmann, 2006; Mahunka and Mahunka-Papp, 2009; Yalçın et al,. 2013; Murvanidze et al., 2020; Toluk and Ayyıldız, 2021).

Scanning electron microscopy studies were conducted at Erciyes University Nanotechnology Application and Research Center (ERNAM). For microscopic examination, the samples cleaned in tergazyme and bleached using lactic acid were examined on a hollow slide under the light microscope, and the measurements of the body parts of the identified mites were made using an ocular micrometer.

The terminology suggested by Norton and Behan-Pelletier (2009) and Ayyıldız and Taşdemir (2019) was followed.

*Information on the habitats of the determined carabodid mites*

13T036: 40°32'44''N 31°28'18''E, 1200 m, moss and lichen on stone; 11.10.2013.

13T070: 40°39'58''N 38°59'52''E, 1994 m, fir tree litter; 12.10.2013.

13T572: 40°25'22''N 39°41'37''E, 1538 m, moss under willow; 25.09.2014.

13T578: 40°25'24''N 39°41'57''E, 1589 m, moss under larch; 25.09.2014.

13T702: 40°41'53''N 39°11' 05''E, 1200 m, litter and moss under fir tree; 15.11.2014.

13T704: 40°41'30''N 39°10'16''E, 920 m, moss and lichen above ground; 15.11.2014.

13T754: 39°48' 25''N 39°22'49''E, 482 m, litter from hazelnut orchard; 16.04.2015.

13T759: 40°41'44''N 39°10'43''E, 1074 m, rotted log and moss; 16.04.2015.

13T760: 40° 41' 44''N 39v 10' 43''E, 1074 m, mossy and grassy soil from open field; 16.04.2015.

13T777: 40°41'06''N 39°03'07''E, 729 m, grassy soil; 16.14.2015.

13T789: 40°22'01''N 39°49'22''E, 1900 m, debris under larch; 14.05.2015.

13T793: 40°22'06''N 39°49'26''E, 1869 m, mixed spill from roadside; 14.05.2015.

13T797: 40°22'12''N 39°49'32''E, 1860 m, moss and grass from bare area; 14.05.2015.

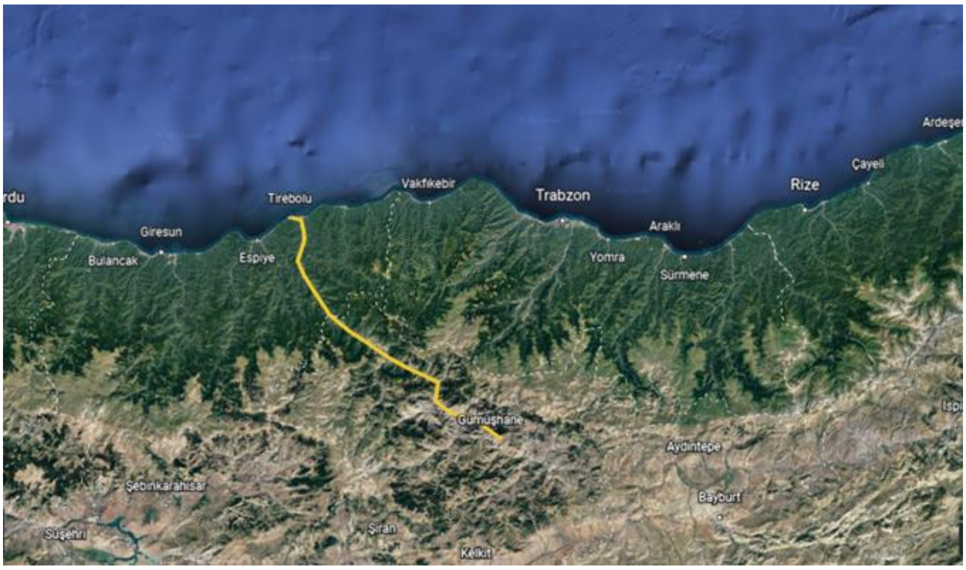


**Figure 1.** Topographic map of the Harşit Valley.

## RESULTS

As a result of the examination of the carabodid mites selected from the material collected in the Harşit Valley in 2013 and 2015, five species, namely *Carabodes* (*C.*) *labyrinthicus* (Michael), *Carabodes* (*C.*) *pirinensis* Kunst, *Carabodes* (*C.*) *rugosior* Berlese, *Carabodes* (*Flexa*) dubius Kulijev and *Carabodes* (*Klapperiches*) *willmanni* Bernini, were determined. Distinctive features of these species are given below, along with scanning electron microscope photographs.

*Identification key for subgenera of the genus Carabodes known from Türkiye*

1. The ventral region short; genital and anal plates located close to each other; aggenital setae not present……………………………………………… *Klapperiches* Mahunka

- Ventral region normal length; genital and anal plates separated in the normal position; aggenital setae mostly present…………………………………………...…………………………………...2

2. The setae $c_2$ long directed forward, all the other notogastral setae short, leaf-shaped; the lyrifissure *iad* located near the anal opening ……………………………..…. *Flexa* Kulijev

- The setae $c_2$ directed outward or backward; no significant difference in length between the setae $c_2$ and other notogastral setae; the lyrifissure *iad* not present or originates away from the anal opening……………...*Carabodes* C.L. Koch

The subgenus *Carabodes* C.L. Koch

Type species: *Carabodes coriaceus* C.L. Koch

*Carabodes* (*C.*) *labyrinthicus* (Michael)

*Body measurements*: Length 558 µm, width 350 µm (n=1).

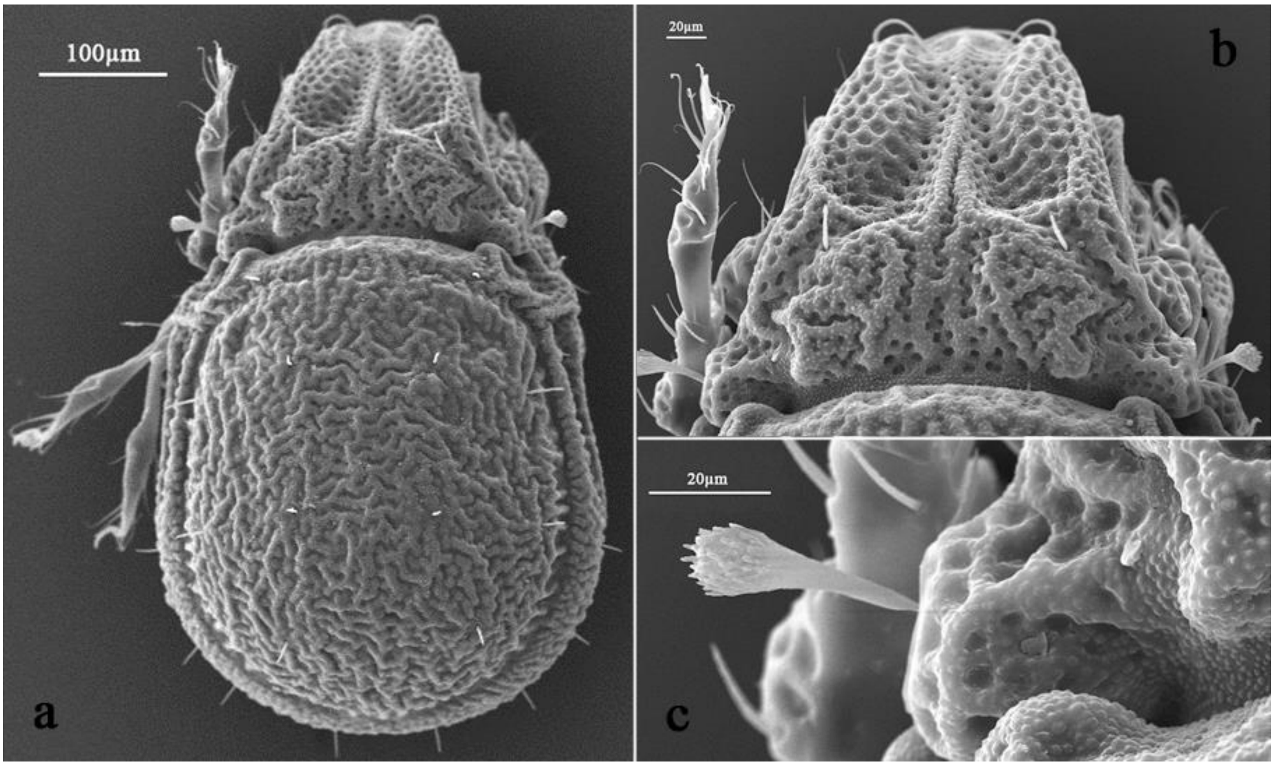


**Figure 2.** *Carabodes* (*C.*) *labyrinthicus* (Michael): **a.** Dorsal view, **b.** Prodorsum, **c.** Sensillus.

*Prodorsum* (Figs 2b, c). Length 175 µm, width 159 µm. Rostrum round; lamellae broad, rostral, and lamellar setae thin, straight, and curved inwards; interlamellar setae rod-shaped, erect, and strong; sensillus rod-shaped and barbed head at the tip. The interlamellar region is equipped with labyrinth-shaped irregular ridges, and besides round pores, the ridges are covered with thin small tubercles.

*Notogaster* (Fig. 2a). Length 383 µm, width 267 µm, oval-shaped, dorsosejugal furrow flat anteriorly; the notogastral region, like the interlamellar region, consists of ridges forming labyrinths and decorated with small tubercles. Dorsosejugal furrow absent. Two prominent humeral projections are directed anteriorly. Notogaster with ten pairs of straight and fine setae. The setae in the middle part are shorter than the setae in the edge.

*Ventral region*. The subcapitulum diarthric; coxisternal setal formula 3–1–2–3. Four pairs of genital setae, one pair of aggenital setae, two pairs of anal setae, and three pairs of adanal setae. Genital setae are short, fine, and straight.

*Material examined*: 13T777: 1 adult.

### *Carabodes* (*C.*) *pirinensis* Kunst

*Body measurements*. Length 420-420 µm, width 240-240 µm (n= 2).

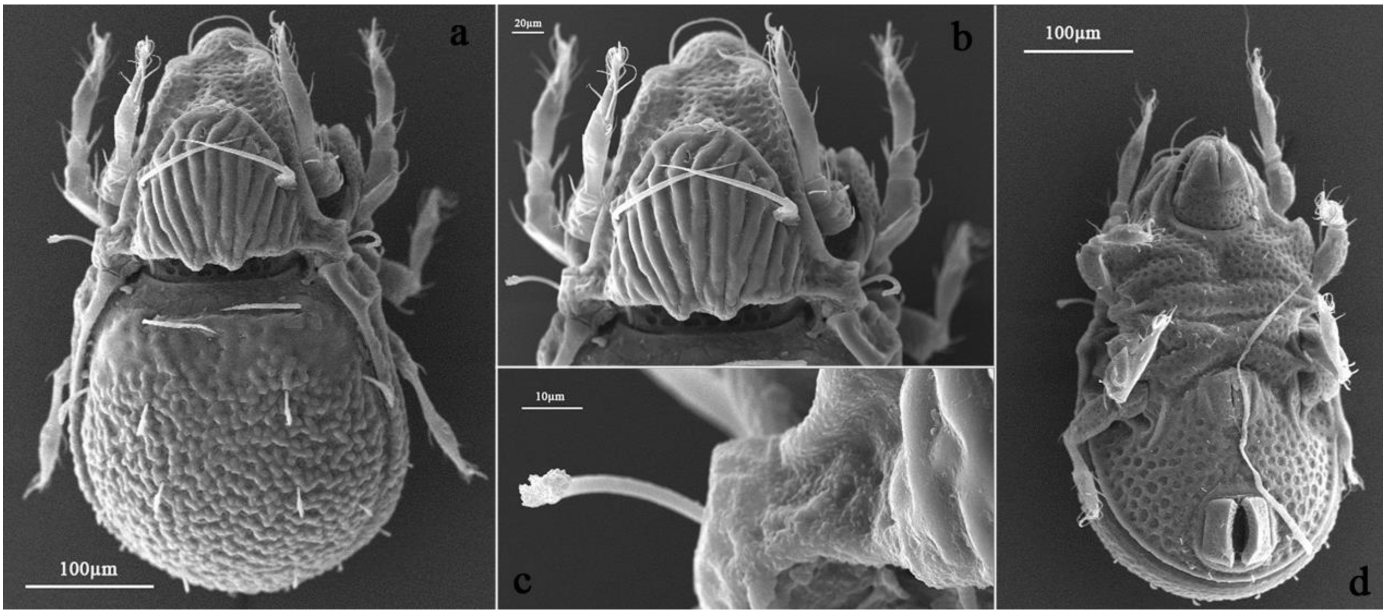


**Figure 3.** *Carabodes* (*C.*) *pirinensis* Kunst: **a.** Dorsal view, **b.** Prodorsum, **c.** Sensillus, **d.** Ventral view.

*Prodorsum* (Figs 3b, c). Rostrum round; rostral setae thin and arched, approximately 41 µm long; the lamellar setae about 33 µm long and robust. The interlamellar setae are 81 µm long, directed inwards, tapering from the base to the tip of the sword, and straight. The lamellar and rostral regions are shallowly pitted and reticulate. The interlamellar region separated from the other regions of the prodorsum by forming a mound with 14 longitudinal, ribbed formations. The mound carries two protrusions in the middle posterior part. Sensillus 28 µm long and uniformly thick stem and a finger-shaped protruding head at the tip.

*Notogaster* (Fig. 3a). Dorsosejugal furrow present. The notogaster has a pair of humeral ridges with small setae and 10 pairs of leaf-shaped ciliated setae. The notogastral cerotegument has a bumpy pattern.

*Ventral region* (Fig. 3d). The subcapitulum diarthric; the mentum, epimeral and genital regions with a reticulated pattern. Coxisternal setal formula 3–1–3–3. Four pairs of genital setae, one pair of aggenital setae, two pairs of anal setae, and three pairs of adanal setae. Genital plates are approximately 50 µm long and wide; the anal plates are about 67 µm long and wide.

*Material examined.*13T036: 2 adults.

*Carabodes* (*C.*) *rugosior* Berlese

*Body measurements*: Range of length 520-530 µm, width 270-280 µm (n=5).

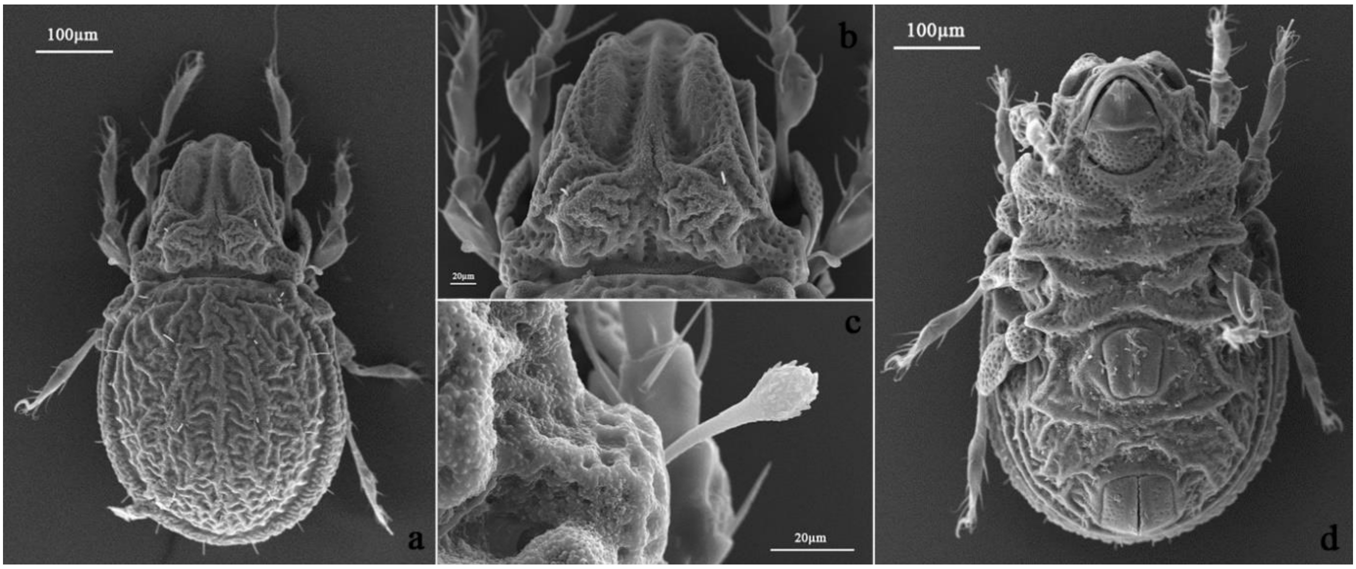


**Figure 4.** *Carabodes* (*C.*) *rugosior* Berlese: **a.** Dorsal view, **b.** Prodorsum, **c.** Sensillus, **d.** Ventral view.

*Prodorsum* (Figs 4b, c). Rostrum round; rostral setae thin and arched inward; interlamellar setae 11 µm long and straight; lamellar setae 35 µm long, curved inwards, straight shaped. Two tubercles in the posterior part of the prodorsum are raised and covered with small mounds; the lamellae are covered with small mounds on chitin ridges and round pits. Sensillus 25 µm long, rod-shaped head with tubercles.

*Notogaster* (Fig. 4a). Ridges are in irregular shapes, one in the middle and one on the sides, and the entire surface is covered with very thin and small tubercles. Notogastral setae thin and straight baciliform, the setae $c_2$ 15 µm, and the other setae a length ranging from 30-35 µm. The dorsosejugal suture is straight and carries anterior humeral prominence on both sides.

*Ventral region* (Fig. 4d). The subcapitulum and epimeral region have a circular porous pattern. The subcapitulum diarthric. The epimeral setae formula 3–1–3–3. The genital plate is 91 µm long and 77 µm wide, with four short and straight setae pairs. The anal plate is 86 µm long and 97 µm wide and carries two pairs of setae.

*Material examined*. 13T754: 5 adults; 13T759: 267 adults (two of them were used in the scanning electron microscopy examination).

The subgenus *Flexa* Kulijev

*Carabodes* (*Flexa*) *dubius* Kulijev

*Body measurements*. Range of length 460-530 µm, width 210-280 µm (n=8).

*Prodorsum* (Figs 5b, c). Rostrum round; rostral setae 40 µm long, slightly curved inward and straight. Lamellar setae short ciliated, interlamellar setae inwardly curved, 113 µm long, and sparsely ciliated. The rostral and lamellar regions are shallow pits, and the interlamellar region is a shallow pit structure with longitudinal and transverse labyrinth-shaped ridges in front. Sensilli a finger-shaped cap at the tip.

*Notogaster* (Fig. 5a). Notogaster surface raised pattern of ridges to form a rosette flower structure. Notogaster setae narrow, leaf-shaped, and spiny in the enlarged part; the setae $c_2$ 100 µm long, anteriorly directed and strong; all other notogastral setae are similar to each other. The dorsosejugal furrow present and about 20 µm wide.

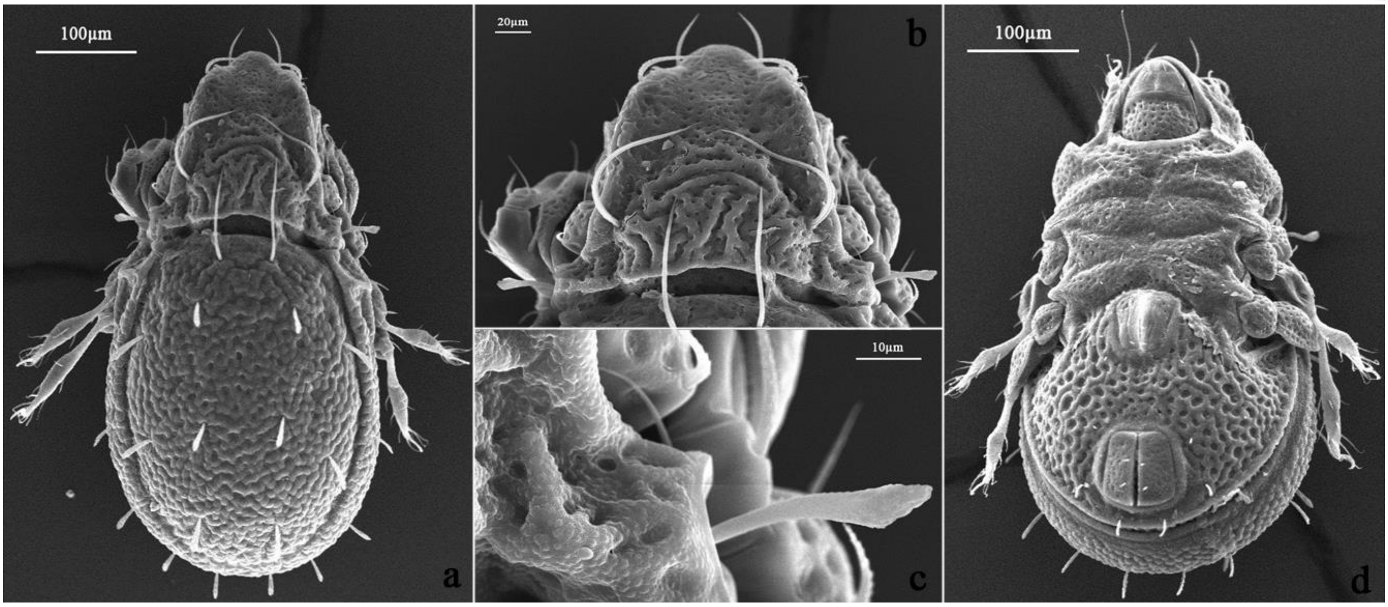


**Figure 5.** *Carabodes* (*Flexa*) *dubius* Kulijev: **a.** Dorsal view, **b.** Prodorsum, **c.** Sensillus, **d.** Ventral view.

*Ventral region* (Fig. 5d). The subcapitulum is diarthric; the mentum region small pits and a reticulate pattern. The epimeral and genito-anal regions also a similar structural pattern. The epimeral setae 3–1–3–3. The genito-anal region setal formulae 4–1–2–3. The genital plate a length of 56 µm and a width of 44 µm. The length and width of the anal plate are about 67 µm.

*Material examined*. 13T070: 2 adults; 13T702: 3 adults; 13T704: 27 adults (three were used in the scanning electron microscopy examination).

### The subgenus *Klapperiches* Mahunka

### *Carabodes* (*Klapperiches*) *willmanni* Bernini

*Body measurements*. Range of length 350-470 µm, width 220-270 µm (n=8).

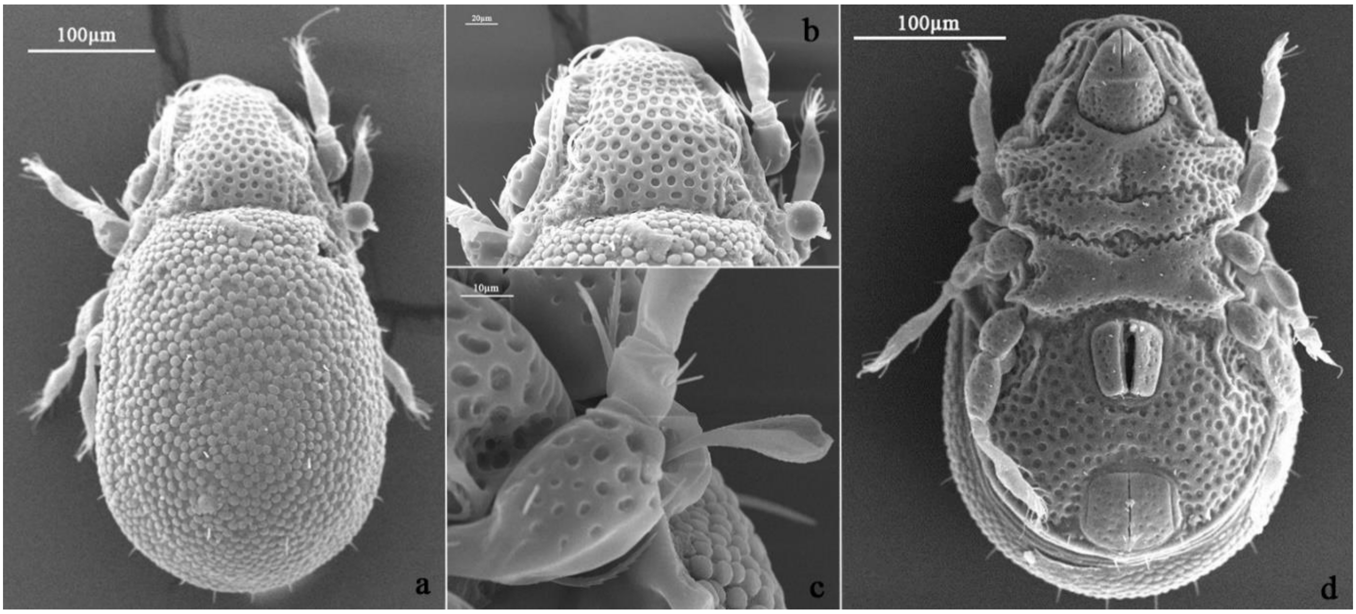


**Figure 6.** *Carabodes* (*Klapperiches*) *willmanni* Bernini: **a.** Dorsal view, **b.** Prodorsum, **c.** Sensillus, **d.** Ventral view.

*Prodorsum* (Figs 6b, c). Rostrum round; rostral and lamellar setae broad and curved inward; interlamellar setae 30 µm long, arcuate, tapering to the tip, rod-shaped and straight; the interlamellar region a network structure consisting of small spaces (pores); sensillus short-stalked (10 µm), club-shaped (25 µm) at the tip, broadly slit in the middle of the head region.

*Notogaster* (Figs 6a, 7a, b). Dorsosejugal furrow absent. The surface of the notogaster is covered with rounded bumps (tubercles) varying between 7-10 µm. Seven pairs of notogaster setae lanceolate and the setae $p_{1\text{-}3}$ short and thin. The length of notogastral setae varies between 15-20 µm.

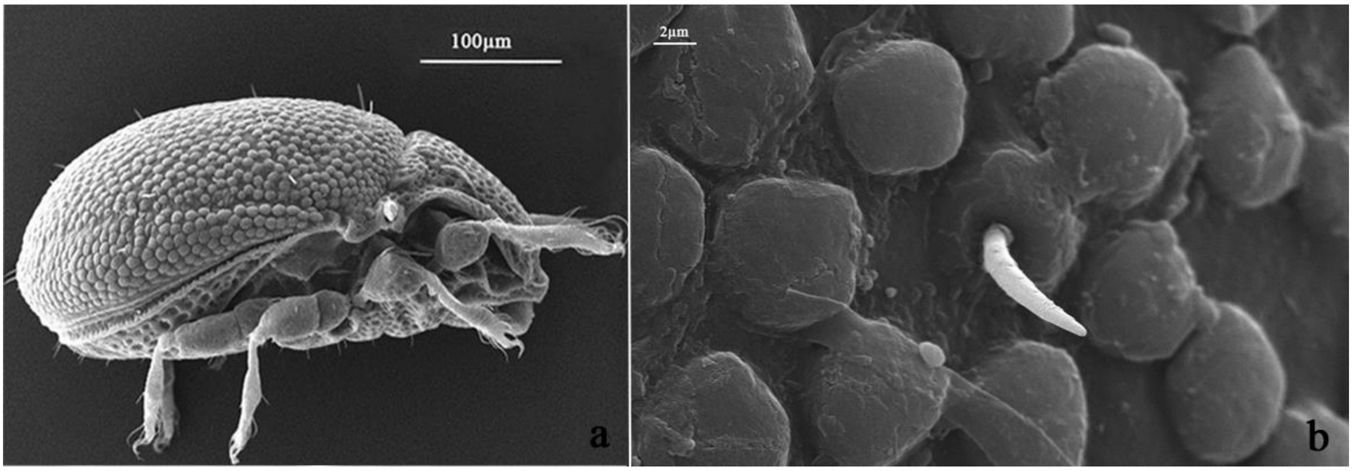


**Figure 7**. *Carabodes* (*Klapperiches*) *willmanni* Bernini: **a.** Lateral view, **b.** Notogastral seta.

*Ventral region* (Fig. 6d). The subcapitulum diarthric and the mentum region have a small porous pattern. Like the mentum region, the epimeral region has a small porous pattern. The distribution of the setae in the epimeral region 3–1–3–3. The genital plate is 53 µm long and 47 µm wide and bears four pairs of setae. The anal plate is 53 µm long, 66 µm wide and has two pairs of setae. The genito-anal area is covered with a circular pitted pattern.

*Material* examined. 13T036: 78 adults; 13T572: 1 adult; 13T578: 2 adults; 13T702: 5 adults; 13T704: 7 adults; 13T760: 3 adults; 13T777: 1 adult; 13T789: 1 adult; 13T793: 5 adults; 13T797: 3 adults (three of them were used in the scanning electron microscopy examination).

## DISCUSSION

The five carabodid mite species mentioned here are discussed below, considering their zoogeographic distribution and taxonomic features.

*Carabodes* (*C.*) *labyrinthicus* (Michael). It is commonly distributed in the Holarctic region and Mexico (Bulanova-Zakhvatkina, 1975; Subías, 2004). It was previously recorded in Bolu province in Türkiye (Toluk and Ayyıldız, 2021).

This species can be distinguished by its irregularly raised prodorsal structure, spiny-rod-shaped sensillus, the absence of dorsosejugal furrow, the notogaster pattern equipped with articulated tubercles, and the short genital setae (Weigmann, 2006; Murvanidze, 2008).

The body length for this species varies between 430-608 µm. In this respect, it was determined as 558 µm in the samples examined, and it is understood that it is within the known range. It has been determined that the features given by various researchers for this species are generally in concordance with the features of our specimens (Weigmann, 2006; Murvanidze, 2008; Toluk and Ayyıldız, 2021).

*Carabodes* (*C.*) *pirinensis* Kunst. It spreads in Bulgaria and Türkiye in the Palearctic region (Kunst, 1961; Subías, 2004; Toluk and Ayyıldız, 2021). It was previously recorded from Bolu province in Türkiye (Toluk and Ayyıldız, 2021). Harşit Valley is the second locality record in our country.

Its long, strong, straight interlamellar setae can easily distinguish this species. It is separated from the other parts of the prodorsum by the mound formed by the ridges arranged to form a longitudinal groove, varying between 8-14.

Body measurements (length x width) for type specimens are 570-604 x 330-370 µm (Kunst, 1961). For previously recorded samples from Türkiye, body measurements were given as 504-560 x 272-320 µm and reported to be smaller (Toluk and Ayyıldız, 2021). In the samples we examined, the body length was measured as 420 µm and the width as 240 µm, the smallest recorded size. The setae $ps_{1-3}$ and $r_3$ were reported to be rod-shaped with denticles for Bolu samples (Toluk and Ayyıldız, 2021), whereas it was reported to be leaf-shaped in the original shape and description given by Kunst (1961). In the examined samples, these setae appear to be similar to those described by Kunst (1961). Apart from this, it has been determined that it is in accordance with the previous definitions regarding other characteristics.

*Carabodes* (*C.*) *rugosior* Berlese. It spreads in the Holarctic region (Bulanova-Zakhvatkina, 1975; Reeves and Behan-Pelletier, 1998; Subías, 2004; Murvanidze, 2008; Kagainis, 2010; Hågvar et al., 2014). It was previously recorded from Bolu province in Türkiye (Toluk and Ayyıldız, 2021).

This species is distinguished by having two tubercle patterns on the posterior part of the prodorsum, the sensillus being in the shape of a flat finger, the absence of dorsosejugal furrow, one long and the other covered with an irregularly raised pattern in the notogaster, normal setae $c_2$, and short and thin genital setae.

The body length varies between 480-650 µm (Weigmann, 2006; Murvanidze, 2008; Toluk and Ayyıldız, 2021). Our sample measured the body length as 520-530 µm and the width as 270-280 µm, which was compatible with known studies. In terms of other features, it generally agrees with the previously reported features of the species (Reeves and Behan-Pelletier, 1998; Weigmann, 2006; Murvanidze, 2008; Toluk and Ayyıldız, 2021).

**Table 1.** The main distinguishing features of *Carabodes minusculus* and *C. wilmanni*.

| Features | *Carabodes wilmanni* | *Carabodes minusculus* |
|---|---|---|
| Body length (µm) | 310–450 | 340–385 |
| Prodorsum pattern | Areolate | Tuberculate |
| Setae length (µm) | 30 | 45 |
| *in* setae shape | Straight, tapered bar | Straight, rod-shaped |
| Sensillus shape | Short shank end stick | Rod-shaped |
| Dorsosejugal furrow | Not available | Not available |
| Notogaster pattern | Tuberculate | Tuberculate |
| *ng* setae length (µm) | 15-20 | 15-25 |
| *ng* setae shape $c_2$ | Lanceolate | Phylliform |
| $c_2$ setae | Normal | Normal |
| Genital setae | Short | Short |
| $p_{1-3}$ setae | Short and thin | Short and thick |

*Carabodes* (*Flexa*) *dubius* Kulijev. This species is distributed in the Caucasus in the Palearctic region (Kulijev, 1977; Subías, 2004; Murvanidze, 2008). It was previously recorded from Bolu province in Türkiye (Toluk and Ayyıldız, 2021).

Several longitudinal grooves distinguish this species in the interlamellar region, the setae $c_2$ being anteriorly directed and strong and the other nine pairs of notogaster setae being leaf-shaped and spiny. This species' body length was 420-517 µm by Murvanidze (2008) and 422-474 µm by Kulijev (1977). Toluk and Ayyıldız (2021) reported that the body size of the samples they collected from Bolu province was 396 x 225 µm and reported that they were small. In our samples, the body length was measured as 460-530 µm and the width as 210-280 µm, and it is understood to be slightly larger than the known ones. In terms of other features, it has been determined that our samples are generally compatible with the features in the definitions given by various researchers before (Kulijev, 1977; Murvanidze, 2008; Toluk and Ayyıldız, 2021).

*Carabodes* (*Klapperiches*) *willmanni* Bernini. This species is distributed in the Holarctic region (Bernini, 1975; Pérez-Íñigo, 1997; Subías, 2004). It was determined as a new record for the fauna of Türkiye.

This species is distinguished by the small pore pattern of the prodorsum region, rod-shaped and flat interlamellar setae, club-shaped sensillus, absence of dorsosejugal furrow, notogaster pattern with rounded tubercles, notogaster setae in lanceolate form, normal $c_2$ setae and short genital setae (Murvanidze, 2008). Body length for this species varies between 310-450 µm (Bernini, 1975; Murvanidze, 2008). In our samples, the body length was measured as 350-470 µm and the width as 220-270 µm, and it is understood that it is within the range of variation generally known for this species. Our samples are in perfect harmony with the characteristics of the species given by Bernini (1975) and Pérez-Íñigo (1997).

*C. minusculus* and *C. wilmanni* are two closely related species. The distinguishing features of these two species are given in the Table 1 by comparing them.

As can be seen from the table, the most distinctive feature is the prodorsum pattern and the shapes of the notogastral setae.

## Authors' contributions

**Büşra Arık:** Investigation, validation, visualization, writing-original draft, writing-review and editing. **Nusret Ayyıldız:** Conceptualization, supervision, validation, writing-original draft, writing-review and editing.

This study is a part of the primary author's MSc thesis.

## Statement of ethics approval

Not applicable.

## Conflict of interest

The authors declare that there are no conflicts of interest.

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RESEARCH ARTICLE

# A preliminary report with new records of feather mites (Acariformes: Astigmata) collected from birds ringed at Boğazkent Bird Ringing Station (Antalya, Türkiye)

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**ASBTRACT:** Feather mites (Astigmata: Analgoidea, Pterolichoidea) are arthropods that live parasitically or commensal on the wing, tail and body feathers of birds. These mites have high host specificity and diversity. Here we studied feather mites collected from birds subjected to ectoparasitic examination during ringing at the Boğazkent Bird Ringing Station (Antalya, Türkiye). Feather mite infestation was detected in 50 of 103 hosts representing 30 species during the study. As a result of microscopic examinations, 16 feather mites were identified, five of which are new records for Türkiye: *Dermonoton parallelus* (Mégnin and Trouessart, 1884), *Gymnolichus secundus* Černý and Schumilo, 1973, *Proctophyllodes anthi* (Vitzthum, 1922), *Pteronyssus robini* (Faccini and Atyeo, 1981), and *Pteroherpus africanus* Mironov and Kopij, 2000. Additionally, new host-parasite associations for the feather mite fauna of Türkiye were revealed in the species *Dolichodectes edwardsi* (Trouessart, 1885), *P. clavatus* Fritsch, 1961, *P. pinnatus* (Nitzsch, 1818), and *Trouessartia kratochvili* Černý, 1979.

**Keywords:** Acarofauna, avian parasite, bird parasite, first record, host-parasite association
**Zoobank:** https://zoobank.org/7C6E391E-754D-4B8F-A6E4-501459B3A83C

## INTRODUCTION

Feather mites (Acariformes: Astigmata: Analgoidea, Pterolichoidea) are arthropods that commonly infest birds with over 2600 identified species in 36-38 families and over 500 genera (Gaud and Atyeo, 1996; Mironov, 2003a; OConnor, 2009; Schatz et al., 2011; Rodrigues et al., 2015). These mites are permanent arthropods that live as commensal or ectoparasites on birds and have extremely high host specificity (Gaud and Atyeo, 1996; Dabert and Mironov, 1999). Generally transmitted from parents to fledgeling vertically or by contact outside the nest, and rarely by phoresis, the nutritional content of these mites consists of fungi and bacteria found on feathers (Doña et al., 2017, 2019). Dependent on their hosts, feather mites have developed a number of morphological (e.g. flattened body to avoid falling from feathers, wide interlocked legs: ambulacra, hooked spines on body and legs) and behavioral (move away from feathers about to fall) adaptations to survive (Mironov, 1999; Proctor, 2003; Jovani and Serrano, 2004).

The aim of this study is to report the feather mites detected in birds at the Boğazkent Bird Ringing Station (Antalya, Türkiye).

## MATERIALS AND METHODS

This study was conducted at Boğazkent Applied Environmental Education and Bird Ringing Station (Antalya, Türkiye) during the spring 2024 ringing studies. Sampling studies were carried out after obtaining legal permissions from the Republic of Türkiye Ministry of Agriculture and Forestry, General Directorate of Nature Conservation and National Parks (21264211-288.04-11857750). Before the ringing process, the hosts were subjected to ectoparasite examination under a stereo microscope (Leica EZ4, Wetzlar, Germany). Mite specimens were carefully collected from the hosts using blunt-ended forceps.

Afterwards, the specimens were stored in Eppendorf tubes containing 70% ethanol until microscopic identification. In the identification stages, first a representative number of mite specimens were cleaned with lactophenol for 48 hours and then slides were prepared using Hoyer's medium (Evans, 1992). Finally, feather mites were identified under the light microscope (MIC-B30/B Binocular 45 Economic Microscope-Led-Achromat, Soif Optical Instruments Factory, China) in the light of relevant literature (Atyeo and Braasch, 1966; Santana, 1976; Gaud, 1980; Mironov, 1985, 2002; Badek and Dabert, 2005; Mironov and Wauthy, 2008; Burdejnaja and Kivganov, 2009; Mironov et al., 2015).

Mite specimens were photographed using the integrated camera of the light microscope. All scale bars on the figures are given in micrometres (µm). In addition, a slide of each identified species is deposited both in Pamukkale University, Faculty of Science, Department of Biology, Acarology Laboratory (Denizli, Türkiye) and in G. Eren's personal collection.

## RESULTS

During the ectoparasitic examination, feather mite infestation was detected in 50 hosts from 19 species belonging to five orders. While infestation of only one species was detected in 13 host species, infestation of at least two species was detected in six host species. On the other hand, *Dolichodectes edwardsi* (2 hosts) and *Proctophyllodes clavatus* (4 hosts) species were detected in more than one host.

As a result of microscopic examination, seven species from the Proctophyllodidae family, three species from the Trouessartiidae family, two species from the Pteronyssidae family, one species each from the Analgidae, Avenzoariidae, Kramerellidae and Pterolichidae families were identified. Among these species, *Dermonoton parallelus* (Mégnin and Trouessart, 1884), *Gymnolichus secundus* Černý and Schumilo, 1973, *Proctophyllodes anthi* (Vitzthum, 1922), *Pteronyssus robini* (Faccini and Atyeo, 1981), and *Pteroherpus africanus* Mironov and Kopij, 2000 are new records for the feather mite fauna of Türkiye.

## DISCUSSION

Feather mites are generally overlooked by the Turkish parasitology studies compared to other ectoparasites of birds (ticks and chewing lice). More than 10 studies have been conducted in Türkiye so far, but since these studies were mostly conducted on birds in narrow scopes and limited regions, the feather mite fauna of Turkish birds has not been sufficiently revealed. The first comprehensive study was conducted by Gürler et al. (2013) at the Cernek Ringing Station (Kızılırmak delta, Samsun), in which 196 individual hosts from 42 bird species were examined and 30 feather mite species were identified. All species of feather mites detected in this study were presented as new records for Türkiye. The second comprehensive study was conducted at the same station by Per and Aktaş (2018). In this study, 591 individual hosts from 10 warbler (Sylviidae) species were examined and 10 feather mite species were identified. Only one of these mites was reported as a new record for Türkiye. Finally, in the study conducted by Eren et al. (2023), 59 individual hosts from 28 bird species were examined and 18 feather mite species were identified. 11 of these mites were presented as new records for Türkiye. Except from these studies, together with other small-scale studies (Özkan et al., 2017; Eren and Açıcı, 2022; Eren et al., 2022), more than 50 feather mite species in 15 families (Alloptidae, Analgidae, Avenzoariidae, Dermoglyphidae, Eustathiidae, Falculiferidae, Freyanidae, Gabuciniidae, Kramerellidae, Proctophyllodidae, Pterolichidae, Pteronyssidae, Ptiloxenidae, Psoroptoididae, Trouessartiidae) have been reported in Türkiye so far.

The family Analgidae Trouessart and Mégnin, 1884 includes over 200 species in 34 genera that cause infestation in many bird orders (e.g. Apterygiformes, Coliiformes, Columbiformes, Coraciiformes, Cuculiformes, Gruiformes, Piciformes, Galliformes, Strigiformes, Passeriformes, Tinamiformes) (Gaud and Atyeo, 1996; Chang et al., 2018; Mironov, 2019; Schatz et al., 2011; Pedroso and Hernandes, 2018; Mironov, 2021; Waki et al., 2024). *Analges* Nitzsch, 1818 is the first identified feather mite genus among feather mites and contains over 60 identified species associated with the order Passeriformes (Mironov, 2019). As a result of studies conducted in Türkiye, the following four species were reported from this genus: *Analges mucronatus*, *A. passerinus*, *A. spiniger* and *A. turdinus* (Eren and Açıcı, 2022).

The family Avenzoariidae Oudemans, 1905 comprises 3 subfamilies in the common taxonomic classification with 37 genera and approximately 170 species (Faccini and Atyeo, 1981; Mironov, 1991). Feather mites in the subfamilies Avenzoariinae and Bonnetellinae are associated with aquatic bird orders such as Charadriiformes, Procellariiformes, Pelecaniformes and Ciconiiformes, while species in the subfamily Pteronyssinae are associated with terrestrial bird orders such as Passeriformes, Piciformes and Coraciiformes (Gaud and Atyeo, 1996). However, Mironov and Dabert (1999) consider the subfamily Pteronyssinae as a separate family. The genus *Avenzoaria* Oudemans, 1905 includes 15 species identified to be associated with birds in the order Charadriiformes (Badek and Dabert, 2005). *Avenzoaria totani* (Canestrini, 1878), which was also identified in this study, has been reported in many bird species from the Anatidae and Scolopacidae families in previous studies in Africa (Cameroon, Congo) (Gaud and Mouchet, 1959; Gaud, 1972), Asia (Korea, Russia) (Dubinin, 1951; 1956; Vasjukova and Mironov, 1991; Han and Min, 2019), and Europe (Italy, Poland, Türkiye) (Canestrini, 1878; Dubinin, 1956; Dabert, 1992, 2000; Badek and Dabert, 2006; Gürler et al., 2013).

The family Kramerellidae Gaud and Mouchet, 1961 includes the genera *Dermonoton* Gaud and Mouchet, 1959, *Kramerella* Trouessart, 1916 and *Petitota* Gaud and Mouchet, 1959, which infest owls (Strigiformes) (Gaud, 1980; Philips, 2000). Of these genera, *Dermonoton* includes six described species (Mégnin and Trouessart, 1884; Gaud and Mouchet, 1959; Gaud, 1980). *Dermonoton parallelus* (Mégnin and Trouessart, 1884), found on the scops owl (*Otus scops*) in the present study, is a new record for Türkiye. This species was previously reported from *Asio capensis* (Smith, 1834) (Cameroon), *Asio otus* (Linnaeus, 1758) (North Africa), *Bubo africanus* (Temminck, 1821) (Democratic Republic of Congo, Mozambique, Rwanda and Zimbabwe) and *Bubo lacteus* (Temminck, 1820) (Republic of Botswana) hosts (Philips, 2000).

The family Proctophyllodidae Trouessart and Mégnin, 1884 is the richest family among feather mites with 50 genera and over 500 species (Proctophyllodinae and Pterodectinae) (Mironov, 2009; Hernandes and Valim, 2014). The genus *Proctophyllodes* Robin, 1877 is the most specious genus both in this family and among all feather mites (Atyeo and Braasch, 1966; Mironov, 2012; Sun et al., 2023). It is also the genus with the highest number of feather mites reported in Türkiye (Gürler et al., 2013; Per and Aktaş, 2018; Eren and Açıcı, 2022; Eren et al., 2023). In the present study, *Proctophyllodes anthi* (Vitzthum, 1922) found on the neck-turning bird (*Jynx torquilla*) and the red-throated pipit (*Anthus cervinus*) is a new record for Türkiye. The genus *Dolichodectes* Park and Atyeo, 1971 contains ten species associated with birds from the order

Passeriformes (Acrocephalidae, Monarchidae, Phylloscopidae, Platysteiridae, Muscicapidae, Turdidae and Ploceidae) (Mironov and Fain, 2003, Mironov et al., 2010, 2012, 2015).

The family Pterolichidae Trouessart and Mégnin, 1884 is one of the largest families of mites that infest species in 120 genera with over 400 species in 12 non-passeriform bird orders (Gaud and Atyeo, 1996). The genus *Gymnolichus* Gaud and Mouchet, 1961 is also one of the smallest genera in this family and includes two species described in the nightjars (Caprimulgiformes: Caprimulgidae): *Gymnolichus anadorus* Gaud and Mouchet, 1961 and *Gymnolichus secundus* Černý and Schumilo, 1973 (Gaud and Mouchet, 1961; Černý and Schumilo, 1973; Gaud, 1980*). Gymnolichus secundus*, identified in this study from the nightjar (*Caprimulgus europaeus*), is a new record for Türkiye.

The family Pteronyssidae Oudemans, 1941 includes approximately 150 species described in 23 genera associated with birds classified in the orders Passeriformes, Piciformes and Coraciiformes (Mironov, 2003b; Mironov and Wauthy, 2005, 2008). Of these genera, *Pteronyssus* includes five species that infest species in the woodpeckers (Picidae) genera *Dendrocopos*, *Melanerpes*, *Picus* and *Picoides*: *Pteronyssus brevipes* Berlese, 1885, *P. centurus* McDaniel and Price, 1963, *P. dubinini* Černý and Schumilo, 1973, *P. picoides* Černý and Schumilo, 1973 and *P. robini* (Faccini and Atyeo, 1981). Among these species, *P. robini* was firstly reported from Türkiye in this study on the lesser woodpecker (*Dryobates minor*), and in previous studies it was identified in the woodpeckers *Picus viridis* (Switzerland, Moldova and Russia), *Picus canus* (Russia), *Dendrocopos major* (Russia), *Dendrocopos medius* (Moldova) and *Dryobates minor* (Russia) (Mironov, 2002). The genus *Pteroherpus* Gaud, 1981, one of the richest genera in its family, contains over 20 species identified so far related to birds in the Passeriformes order (Cisticolidae, Pycnonotidae, Sylviidae, Timaliidae, Zosteropidae, Muscicapidae, Monarchidae and Paradisaeidae) (Faccini and Atyeo, 1981; Mironov and Wauthy, 2008; Mironov, 2011; Mironov and Proctor, 2011; Constantinescu et al., 2014, 2019). With this study, *Pteroherpus africanus* Mironov and Kopij, 2000 was detected on the Arabian nightingale (*Pycnonotus xanthopygos*) for the first time in Türkiye and in the world. Previously, it was reported from *Pycnonotus barbatus* (Morocco and South Africa) and *Pycnonotus nigricans* (South Africa) hosts (Mironov and Wauthy, 2008).

The family Trouessartiidae Gaud, 1957 includes approximately 170 species, mainly associated with birds in the order Passeriformes, but also with birds belonging to the orders Piciformes, Coraciiformes and Caprimulgiformes (Orwig, 1968; Santana, 1976; Hernandes, 2014; Mironov et al., 2023). Members of the genus *Trouessartia* Canestrini, 1899 include approximately 150 species identified as related to birds belonging to the orders Piciformes, Charadriiformes, Gruiformes and Psittaciformes, predominantly Passeriformes (Mironov, 2022). *Trouessartia* is the second genus with the highest number of reported species in Türkiye, after *Proctophyllodes*, with seven species (Gürler et al., 2013, Per and Aktaş, 2018).

As a result, this study reports new species records and new host-parasite associations for the feather mite fauna of Türkiye. The current study is also the first comprehensive research conducted on the southern coasts of the country (Boğazkent, Antalya). Other comprehensive studies were conducted in the provinces located on the northern coasts of Türkiye. The multidisciplinary studies conducted at ringing stations are crucial for uncovering the diversity of feather mites and the host-parasite relationships across various bird species. These studies are particularly valuable as they allow for the examination of a substantial number of host ectoparasites within a relatively short time frame, typically during the spring or autumn ringing periods.

## Authors' contributions

**Gökhan Eren:** Conception/design of study, methodology (equal), data acquisition, data analysis/interpretation, identification, preservation (equal), drafting manuscript (lead), final approval and accountability (equal). **Esat Kızılkaya:** Methodology (equal), collection of specimens (lead), preservation (equal), final approval and accountability (equal). **Hakan Karaardıç:** Project administration/supervision, methodology (equal), collection of specimens (supporting), preservation (equal), critical revision of manuscript (supporting), final approval and accountability (equal). **Mehmet Karaca:** Methodology (equal), drafting manuscript (supporting), critical revision of manuscript (lead), final approval and accountability (equal).

## Statement of ethics approval

Not applicable.

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## Conflict of interest

Authors declared no conflict of interest.

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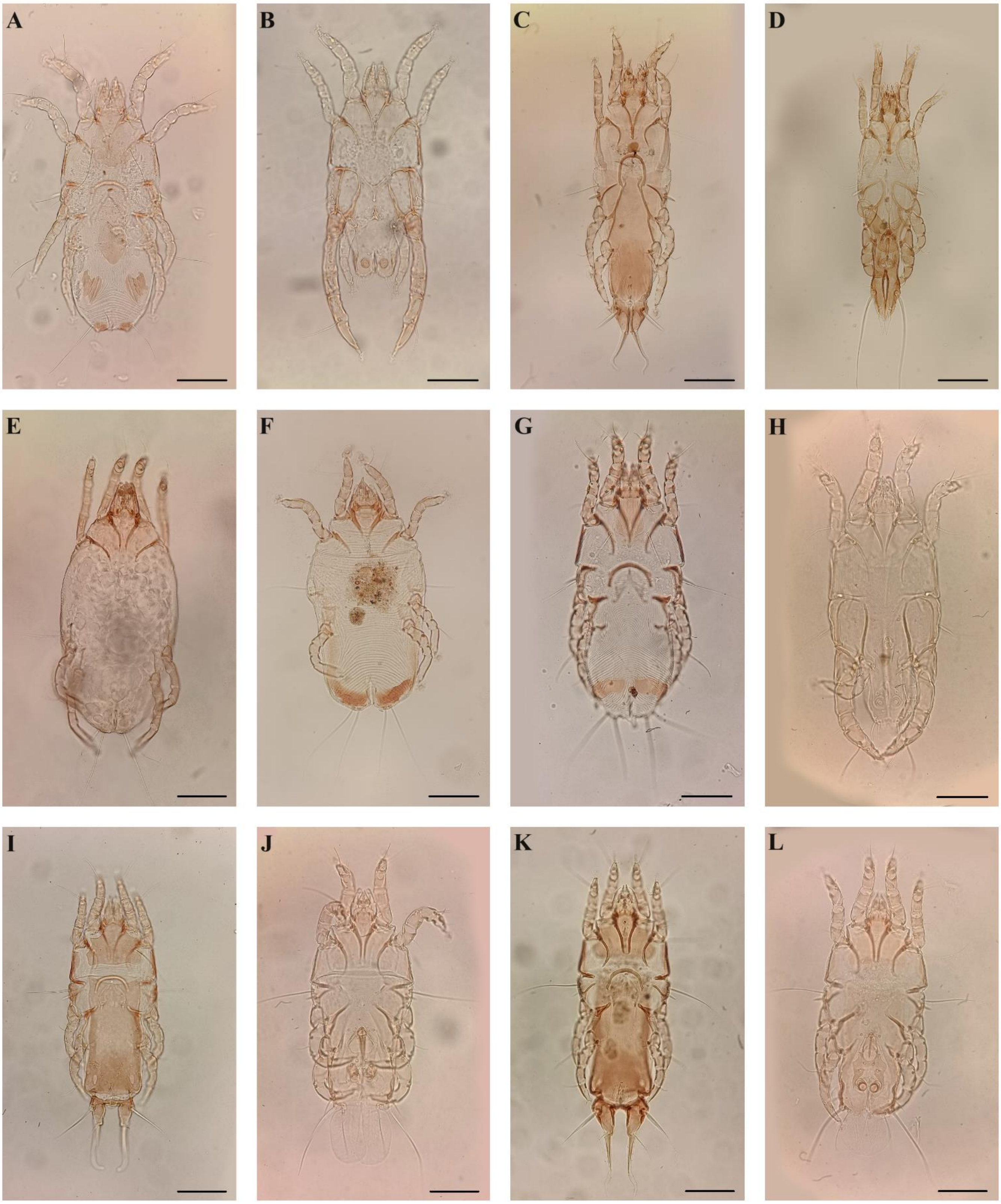


**Figure 1.** The original photographs of the feather mites detected as new records or new host-parasite associations. *Pteroherpus africanus* female (**A**) and male (**B**); *Dolichodectes edwardsi* female (**C**) and male (**D**); *Gymnolichus secundus* tritonymph (**E**); *Dermonoton parallelus* female (**F**); *Pteronyssus robini* female (**G**) and male (**H**); *Proctophyllodes pinnatus* female (**I**) and male (**J**); *Proctophyllodes anthi* female (**K**) and male (**L**) (scale bars: 100).

**Table 1.** Feather mites detected on the avian hosts (*new records for the Turkish fauna, **new host-parasite associations).

| Bird species (number of infected birds) | Bird order | Bird family | Mite species |
|---|---|---|---|
| *Caprimulgus europaeus* (1/1) | Caprimulgiformes | Caprimulgidae | *Gymnolichus secundus** |
| *Tringa glareola* (3/2) | Charadriiformes | Scolopacidae | *Avenzoaria totani* |
| *Otus scops* (1/1) | Strigiformes | Strigidae | *Dermonoton parallelus** |
| *Acrocephalus arundinaceus* (4/4) | Passeriformes | Acrocephalidae | *Dolichodectes edwardsi*<br>*Trouessartia trouessarti* |
| *Acrocephalus schoenobaenus* (6/5) | | | *Dolichodectes edwardsi***<br>*Proctophyllodes clavatus* |
| *Carduelis spinus* (2/1) | | Fringillidae | *Analges passerinus*<br>*Proctophyllodes pinnatus*** |
| *Locustella luscinioides* (1/1) | | Locustellidae | *Proctophyllodes clavatus*<br>*Trouessartia kratochvili* |
| *Locustella fluviatilis* (1/1) | | | *Trouessartia kratochvili* |
| *Anthus cervinus* (5/5) | | Motacillidae | *Proctophyllodes anthi** |
| *Erithacus rubecula* (4/2) | | Muscicapidae | *Proctophyllodes rubeculinus*<br>*Trouessartia rubecula* |
| *Ficedula semitorquata* (1/1) | | | *Proctophyllodes doleophyes*** |
| *Luscinia luscinia* (2/1) | | | *Proctophyllodes lusciniae* |
| *Pycnonotus xanthopygos* (7/7) | | Pycnonotidae | *Pteroherpus africanus** |
| *Curruca hortensis* (5/1) | | Sylviidae | *Proctophyllodes clavatus*** |
| *Curruca nisoria* (7/5) | | | *Proctophyllodes clavatus*** |
| *Sylvia atricapilla* (9/9) | | | *Proctophyllodes sylvia*<br>*Trouessartia bifurcata* |
| *Turdus merula* (3/1) | | Turdidae | *Proctophyllodes musicus* |
| *Dryobates minor* (1/1) | Piciformes | Picidae | *Pteronyssus robini** |
| *Jynx torquilla* (1/1) | | | *Proctophyllodes anthi** |

**The number (n) of infected birds:** *Acrocephalus scirpaceus* (12), *Anthus trivialis* (1), *Cettia cetti* (1), *Chloris chloris* (3), *Curruca communis* (5), *Curruca curruca* (6), *Ficedula albicollis* (1), *Ficedula hypoleuca* (1), *Garullus glandarius* (1), *Lanius nubicus* (4), and *Phylloscopus collybita* (4) from the order Passeriformes.

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RESEARCH ARTICLE

# Two new records for the mite (Acariformes, Oribatida) fauna of Türkiye from Kayseri and Osmaniye provinces

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**ASBTRACT:** The oribatid mite taxa, *Carabodes* (*Carabodes*) *coriaceus* Koch, 1835 and *Scutovertex alpinus* Willmann, 1953 collected from the Olukbaşı Plateau (Osmaniye) and the Derevenk Valley (Kayseri), were determined as new records for the Turkish acarofauna. The morphological features of the related species were reviewed on the basis of the collected specimens, and their known distributions were also given.

**Keywords:** Acari, distribution, morphology, *Carabodes*, *Scutovertex*
**Zoobank:** https://zoobank.org/85E010C5-87E5-4C41-B6AD-C3E05CCB7A33

## INTRODUCTION

Soil invertebrates that affect nutrient cycling by feeding directly on plant materials and organic substrates are a valuable component of biodiversity (Manu et al., 2021). Oribatid mites (Acari, Oribatida) are one of the most dominant groups of soil invertebrates. They mostly consume living or dead plant parts or fungi. They indwell a wide variety of microhabitats, including litter, humus layers, lichens, moss, algae, and fungal cushions, most mate 1-3 times a year, laying 1-6 eggs each time (Norton, 1994, Toluk et al., 2010; Padinhare Kaithayil and Neravathu, 2020; Arabuli and Gogshelidze, 2023). Their densities reach up to 400,000 individuals per square meter in acidic boreal forests (Lu et al., 2024). There are 11,628 species of oribatid mites in 1,328 genera belonging to 166 families that have been described so far (Subías 2004, updated 2024).

*Carabodes* (*C.*) *coriaceus* belongs to the genus *Carabodes* Koch, 1835 (Acari: Oribatida: Carabodidae) which includes about one subspecies and 74 described species (Subías 2004, updated 2024). Members of *Carabodes* are easily recognizable by ten pairs of notogastral setae, seta $c_2$ positioned laterally on notogaster in line with seta *la*, or positioned medially in line with seta *lm*, four to seven pairs of genital setae; none, one, or two pairs of aggenital setae, epimeral setation 3-1-3-3, epimeral depression(s) present or absent, seta $ad_3$ subequal in size and shape to other adanal setae, or different (Reeves and Behan-Pelletier, 1998). So far, only three species belonging to the genus *Carabodes*, *Carabodes* (*C.*) *labyrinthicus* (Michael, 1879), *Carabodes* (*C.*) *pirinensis* Kunst, 1961 and *Carabodes* (*C.*) *rugosior* Berlese, 1916, have been known from Türkiye (Toluk and Ayyıldız, 2021).

To date, 69 species within eight genera of the oribatid mite family Scutoverticidae are known worldwide. Weigmann (2006) reported that species of the genus *Scutovertex* vary in certain morphological features and therefore some specimens are difficult to classify. Later, Pfingstl et al. (2008) reported that intraspecific variation occurs only to a small extent. They are known to inhabit different types of habitats from marine littoral to alpine zone (Murvanidze and Weigmann, 2012). *Scutovertex alpinus* belongs to *Scutovertex* Michael, 1879 (Acari: Oribatida: Scutoverticidae) which includes about 30 described species (Subías 2004, updated 2024). It is the second record of *Scutovertex* from Türkiye (Özkan et al., 1988, 1994; Erman et al., 2007, 2024; Baran et al., 2018). *Scutovertex sculptus* is the first record of this genus from Türkiye, was given from the Erciyes Mountain (Kayseri) (Per and Ayyıldız, 2005).

In this study; mites collected from Olukbaşı Plateau (Osmaniye) and the Derevenk Valley (Kayseri) were evaluated and the morphological characteristics of *Carabodes* (*C.*) *coriaceus* Koch, 1835 and *Scutovertex alpinus* Willmann, 1953, which are new records for the Turkish fauna, were reviewed and it was aimed to contribute to their distribution in the world.

## MATERIALS AND METHODS

The oribatid mites, which constitute the study material, were selected by using Berlese-Tullgren funnels from a total 54 specimens consisting of lichen, moss, litter and soil samples taken from Olukbaşı Plateau, Osmaniye and the Derevenk Valley, Kayseri (Türkiye). Then they were fixed and stored in 70% ethanol.

Microscopic examination of the specimens was performed in glycerine or 1:2 water-lactic acid medium on a CX21 model Olympus light microscope. All measurements are given in micrometers (µm). The FESEM (Field Emission Scanning Electron Microscope) examinations of the identified mites were conducted at Erciyes University Technology Research and Application Center (TAUM).

The examined specimens were labelled and preserved in the acarology collections, Laboratory Technology Program, Mustafa Çıkrıkçıoğlu Vocational School, Kayseri University, Türkiye.

## RESULTS

Family Carabodidae Koch, 1843

Genus *Carabodes* Koch, 1835

***Carabodes* (*C.*) *coriaceus* Koch, 1835** (Figures 1A-H)

*Measurements and colour*. Body length: 580-710, body width: 390-460 (n=6). Colour dark brown to black.

*Prodorsum* (Fig. 1B). There are two massive, prodorsal basal protuberances and medially separated. Long, phylliform and barbed interlamellar setae curve towards the medial ridge and rise laterally to the two prodorsal basal protuberances. The sensillus is thin and long. Exobothridial setae are absent.

*Notogaster* (Fig. 1D). The dorsosejugal suture is wide and deep. The anterior notogastral border bears a pronounced and medial, tooth. The notogaster bears ten pairs of setae.

*Ventral region* (Fig. 1G). Epimeral setation 3-1-3-3. Three pairs of adanal setae, 2 pairs of anal setae, 4 pairs of genital setae and 1 pair of aggenital setae present on ano-genital region. The *iad* lyrifissures are situated laterally near the setae $ad_3$.

*Legs* (Fig. 1F). The legs are monodactylous.

*Material examined*. 12 adult specimens (3 of them were used for FESEM), from soil, Olukbaşı Plateau, Osmaniye, Türkiye, 36°59.58'N 036°17.52 E, 1260 m a.s.l., 29.VI.2023.

*Remarks*. *Carabodes (C.) coriaceus* has previously known from Western Palearctic (frequent) and The United States (Virginia) (Subías 2004, updated 2024). Body sizes are previously given as 475-690 (Baratti and Bernini, 1994) and 565-725 (Murvanidze, 2008). According to our data, the mean value of body size is 410-680. In this respect dimensions of the specimens found in Türkiye are in the range of those of previously known specimens. *C. coriaceus* is differentiated from *C. arduinii* by has relatively thin (thick and/or slightly phylliform) backward-directed marginal notogastral setae. In *C. arduinii*, notogastral setae curved, bigger and phylliform. Also, the adanal setae are thin in *C. coriaceus*, while they are phylliform in *C. arduinii* (Baratti and Bernini, 1994). This is the first record of this species in Türkiye.

Family Scutoverticidae Grandjean, 1954

Genus *Scutovertex* Michael, 1879

***Scutovertex alpinus* Willmann, 1953** (Figures 2A-H)

*Measurements and colour*. Body length: 400-470, body width: 200-290 (n=5). Colour dark brown.

*Prodorsum* (Fig. 2B). The rostral setae are slightly dentate. The lamellae, which are thinly connected to the translamella, are narrow. The lamellar setae spiniform, slightly dentate and bent inwards. The sensillus is thin and long. Interlamellar setae and exobothridial setae are absent.

*Notogaster* (Fig. 2D). The lateral edges of the lenticulus are slightly concave and the posterior part is wider. The notogaster bears ten pairs of setae. Five pairs of lyrifissures present.

*Ventral region* (Fig. 2E). Epimeral setation 3-1-2-2. Three pairs of adanal setae, 2 pairs of anal setae, 6 pairs of genital setae and 1 pair of aggenital setae present on ano-genital region.

*Legs*. Tridactyl. The median claw is noticeably larger than the side claws.

*Material examined*. 8 adult specimens (3 of them were used for FESEM), from litter, Derevenk Valley, Kayseri, Türkiye, 38°43.192'N 035°34.394'E, 1156 m a.s.l., 06.X.2023.

*Remarks*. *Scutovertex alpinus* has previously known from European (Austria and Caucasus) (Subías 2004, updated 2024). Body sizes are previously given as 330-630 (Willmann, 1953) and 276 (268-302) - 494 (477-527) (Pfingstl et al., 2010). Murvanidze and Weigmann (2012) only gave their length as 477-630. According to our data, the mean value of body size is 240-420. When the dimensions of the specimens found in Türkiye are compared with the dimensions of previously known specimens, it is seen that they are smaller than Willmann's (1953) specimens. However, the dimensions of our specimens are in the range of specimens in the last comprehensive redescription study by Pfingstl et al. (2010) and the dimensions of Murvanidze and Weigmann's (2012) specimens. This is the first record of this species in Türkiye. It is the second record of the genera *Scutovertex* in Türkiye.

## Authors' contributions

**Sedat Per:** Investigation, analysis, conceptualization, data curation methodology, visualization, software, writing - original draft. **Zişan Yiğit:** Investigation, analysis, formal analysis, visualization. **Melike Sude Akkaya:** Investigation, analysis, formal analysis, visualization.

## Statement of ethics approval

Not applicable.


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## Conflict of interest

None.


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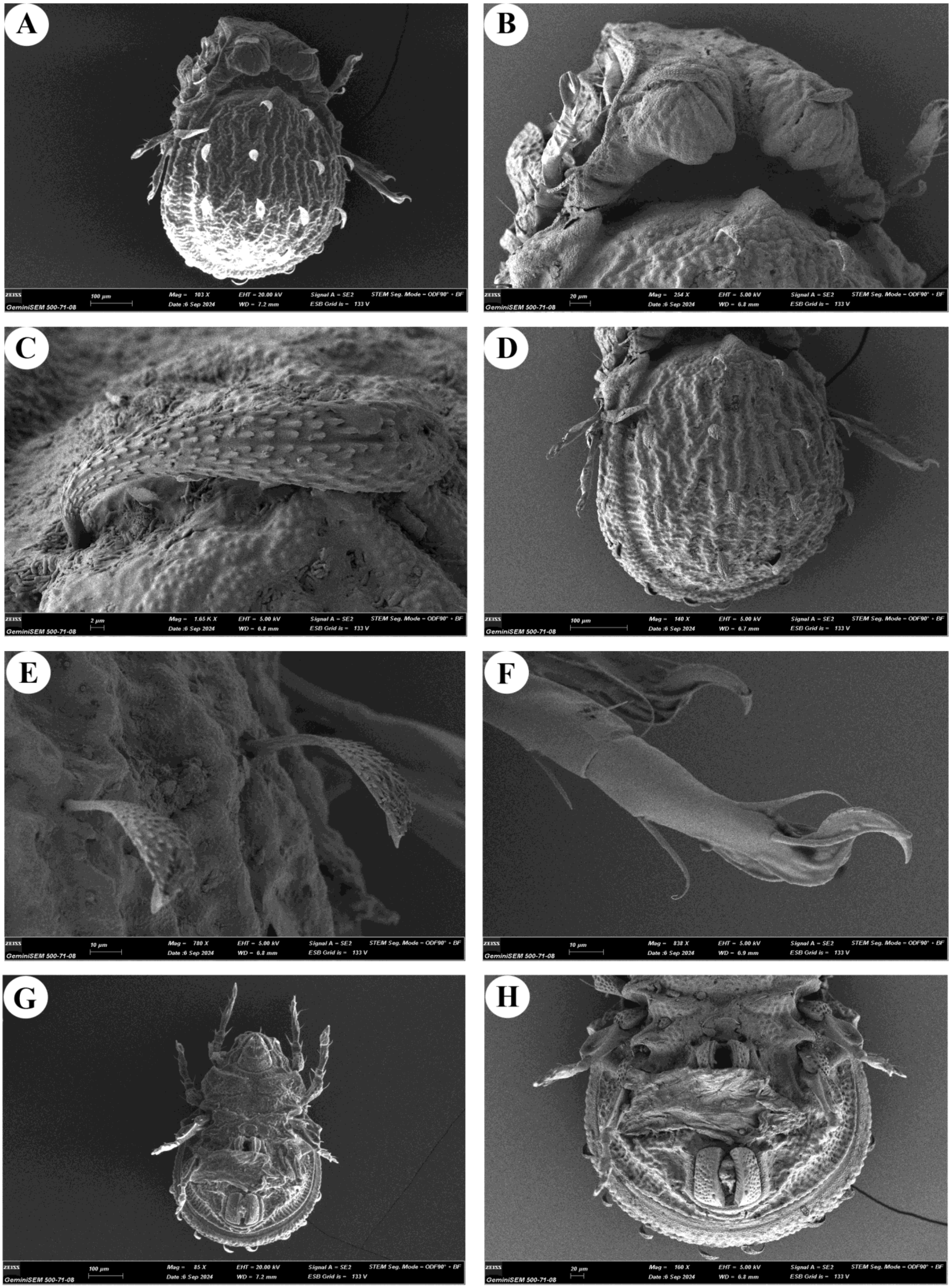


**Figure 1.** *Carabodes* (*C.*) *coriaceus* Koch, 1835. **A.** Dorsal view, **B.** Prodorsum, **C.** Interlamellar setae, **D.** Notogaster, **E.** Setae *lm* and *la*, **F.** Tarsal claw of leg III, **G.** Ventral view, **H.** Ventral view of hysterosoma.

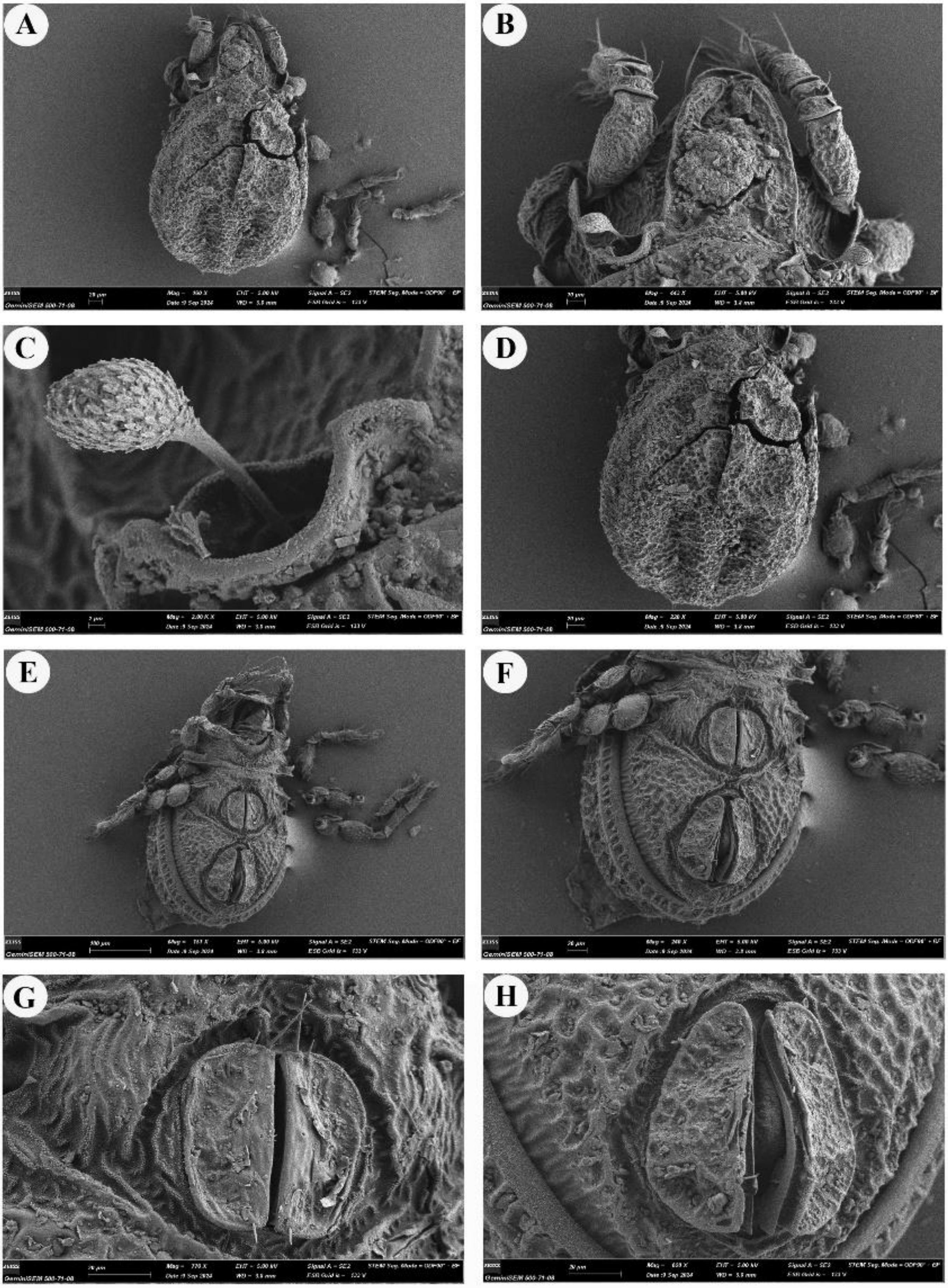


**Figure 2.** *Scutovertex alpinus* Willmann, 1953. **A.** Dorsal view, **B.** Prodorsum, **C.** Sensillus, **D.** Notogaster, **E.** Ventral view, **F.** Ventral view of hysterosoma, **G.** Genital plates, **H.** Anal plates.

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RESEARCH ARTICLE

# Contributions to the fauna of the Turkish oribatid mites (Acari: Oribatida) from Rize province

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**ASBTRACT:** In this study, oribatid mites extracted from soil and litter samples taken from different localities of Rize province in 2019 were evaluated. Four oribatid taxa belonging to the families Trhypochthoniidae, Microzetidae, Crotoniidae and Ceratozetidae were identified. One family (Microzetidae), one subgenus (*Latilamellobates*) and four taxa *Trhypochthonius silvestris europaeus*, *Microzetes* (*Microzetes*) *caucasicus*, *Camisia* (*Camisia*) *biverrucata*, *Trichoribates (Latilamellobates) algarvensis* are newly recorded in Türkiye. Diagnostic features, ecology and biogeographical distribution of each taxon are given with the addition of SEM photographs.

**Keywords:** Distribution, ecology, new record, taxonomy, Türkiye
**Zoobank:** https://zoobank.org/2793A9B6-4E91-4CEC-8026-17F09F9817F8

## INTRODUCTION

Oribatid mites are one of the dominant groups of organisms in forest soils with high organic matter, reaching a density of up to hundreds of thousands of individuals per $m^2$ (Petersen and Luxton, 1982; Behan-Pelletier and Newton, 1999). Due to their contributions to nutrient cycling, soil formation and the breakdown of organic materials, they play a significant biological and ecological role in soil ecosystems. The number of known species and subspecies belonging to this group in the world is 11628 (Subías, 2004, updated 2024), however the estimated number of species vary from 50000 to 100000 (Colloff and Halliday, 1998; Schatz, 2002). Türkiye has around 300 oribatid species (Özkan et al., 1994; Erman et al., 2007, 2024; Baran et al., 2018).

Rize province has a strong natural vegetation and soil characteristics due to its temperate and rainy climate. There are forested areas starting from the coast up to an altitude of 2200 m and subalpine and alpine meadows from this altitude up to 3200 m (Güner et al., 1987). Because of the suitable climate, strong natural vegetation and habitat heterogeneity, Rize has a rich biodiversity. There are no records in the literature on the oribatid mites in Rize. In this study, four oribatid taxa were identified from Rize. This study aims to contribute to the knowledge of the oribatid mite fauna of Türkiye.

## MATERIALS AND METHODS

Soil and litter samples containing oribatid mites were collected from nine localities in Varda plateau and İkizdere district of Rize province, in 2019 (Fig. 1). Each sample was transported to a laboratory and extracted using Berlese-Tullgren funnels in laboratory conditions during 5-7 days. Oribatid mites were separated from the samples under a stereomicroscope (Leica EZ4). For microscopic study, mite specimens were cleared in 60% lactic acid and mounted in Hoyer's medium on glass microscope slides. Observations and measurements of mites were made using a microscope (Olympus BH-2) equipped with a drawing attachment. All measurements are in µm. For scanning electron microscopy (SEM), the mites were air-dried and coated with Au/Pd in a sputter coater and placed on Al-stubs with double-sided sticky carbon tape. Observations and micrographs were made with a ZEISS EVO LS10 scanning electron microscope. Examined materials were transferred into 70% ethanol with glycerol (up to 5%) for the preservation. The morphological terminology follows that of Norton and Behan-Pelletier (2009). The specimens examined are deposited in the Acarological Collection of the Zoological Museum, Erciyes University, Kayseri, Türkiye.

## RESULTS

Four oribatid mite taxa belonging to four families were obtained. All of them are first records for Türkiye. The diagnostic features of these species are given below.

Trhypochthoniidae Willmann, 1931

*Trhypochthonius* Berlese, 1904

***Trhypochthonius silvestris europaeus* Weigmann and Raspotnig, 2009**

*Measurements* (n=5)*:* Body length: 544-608, body width: 360-400.

*Diagnostic features* (Fig. 2): Prodorsal setae *ro (rostral)*, *le (lamellar)*, and *in (interlamellar)* strong, barbed, mean 61, 80, and 96 respectively; sensillus fusiform mean 56; fifteen pairs of barbed notogastral setae; $c_1$ and $c_2$ very short, mean 10, 14 respectively, $c_3$ mean 42, $d_1$, $d_2$ and $d_3$ mean 12, 14, and 29 respectively, $e_1$, $e_2$, $f_2$, and $h_1$ mean 26, 45, 34, and 60 respectively, $p_1$ the longest about 72, $h_3$ and $p_3$ smooth and short; seven pairs of genital setae.

*Material examined*: Varda plateau, Rize province, Türkiye, 40°44' 08.10"N, 40°28' 30.52" E, 2514 m a.s.l., 15.VII.2019,

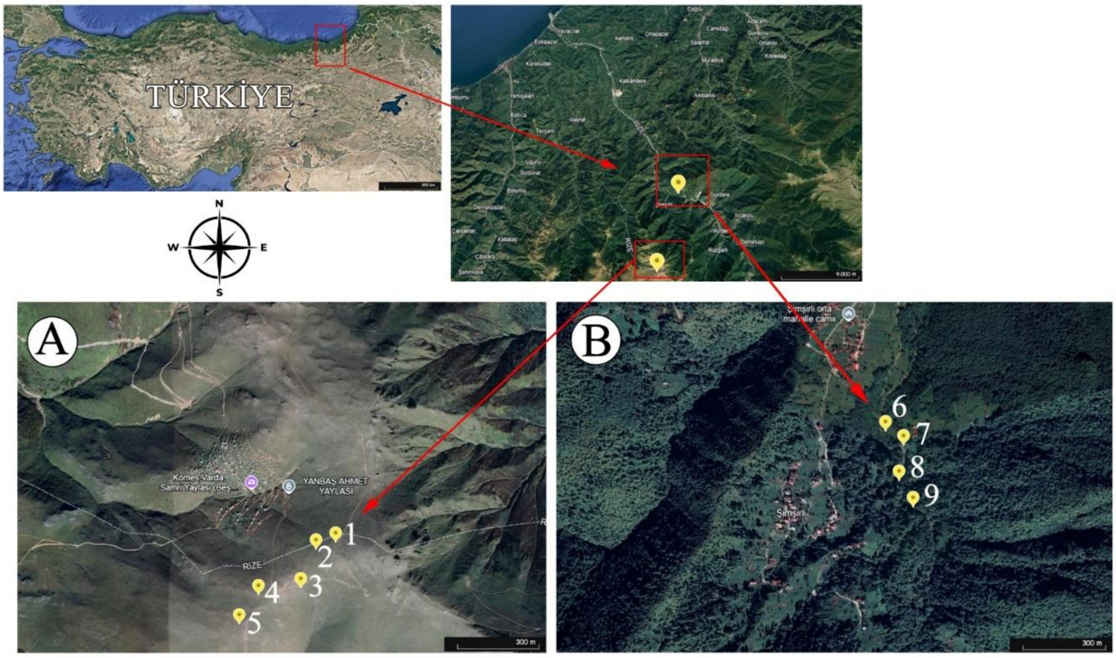


**Figure 1.** Research areas and sampling localities. **A.** Varda plateau, **B.** İkizdere district.

collected from soil with grass, six specimens (one specimen was used in SEM).

Microzetidae Grandjean, 1936

*Microzetes* Berlese, 1913

***Microzetes* (*Microzetes*) *caucasicus* (Krivolutsky, 1967)**

*Measurements* (n=2): Body length: 230-237, body width: 154-160.

*Diagnostic features* (Fig. 3): Setae *in* minute and thin; lamellar setae setiform, inserted on distal parts of lamellae; sensillus setiform, curved tips, ciliate unilaterally in medio-distal parts; lamellae wide, long and distal parts rounded; anterior margin of notogaster slightly convex; notogaster smooth, pteromorphs small with teeth laterally, notogastral setae short, thin; epimeral setal formula 3-1-3-3; six pairs of genital setae.

*Material examined:* İkizdere district, Rize province, Türkiye, 40°48'21.10"N 40°29'13.61"E, 439 m a.s.l., 15.VII.2019, collected from soil and litter in mixed woodland, two specimens (one specimen was used in SEM).

Crotoniidae Thorell, 1876

*Camisia* Heyden, 1826

***Camisia* (*Camisia*) *biverrucata* (Koch, 1839)**

*Measurements* (n=5)*:* Body length: 1052-1094, body width: 440-476.

*Diagnostic features* (Fig. 4). Body covered with cerotegument; setae *le* inserted on long apophysis extending almost to tips of setae *ro*; setae *le* spinose; setae *in* short; sensillus head elongated and covered in tubercles; dorsal notogastral plate oblong and lateral edges parallel; posterior ridges shaped like inverted 'W'; $p_1$ setae inserted in a funnel-shaped caudal lobes and relatively close to each other; transverse median ridge absent between setae $e_1$; nine pairs of genital setae.

*Material examined*: Varda plateau, Rize province, Türkiye, 40°44'08.10"N 40°28'30.52"E, 2514 m a.s.l., 15.VII.2019, collected from soil with grass, two specimens; İkizdere district, Şimşirli Village, 40°48'21.10"N 40°29'13.61"E, 439 m a.s.l., 15.VI.2019, collected from soil and litter in mixed woodland, four specimens (one specimen was used in SEM).

Ceratozetidae Jacot, 1925

Trichoribates Berlese, 1910

***Trichoribates* (*Latilamellobates*) *algarvensis* (Subías and Gil-Martín, 1990)**

*Measurements* (n=1): Body length: 421, body width: 277.

*Diagnostic features* (Fig. 5): Rostrum rounded; setae *ro* long and ciliated, basal part of rostral seta covered by tutorium; lamellae wide and rough, with short translamella; lamellar cusps wide, outer teeth of cusps rounded, setae *la* ciliated and arising from the tip of the lamellar cusps; setae *in* robust, ciliated, not reaching the cusp of lamella, inserted on anterior margin of notogaster; sensillus with short stalk and short clavate head; bothridium hidden under the anterior margin of notogaster; pattern of notogaster reticulate; 10 pairs of notogastral setae; setae $c_2$ as long as *la,* the $c_2$ pair being slightly longer than other notogaster setae.

*Material examined:* Varda plateau, Rize province, Türkiye, 40°44'08.10"N 40°28'30.52"E, 2514 m a.s.l., 15.VII.2019, collected from soil with grass, one specimen (one specimen was used in SEM).

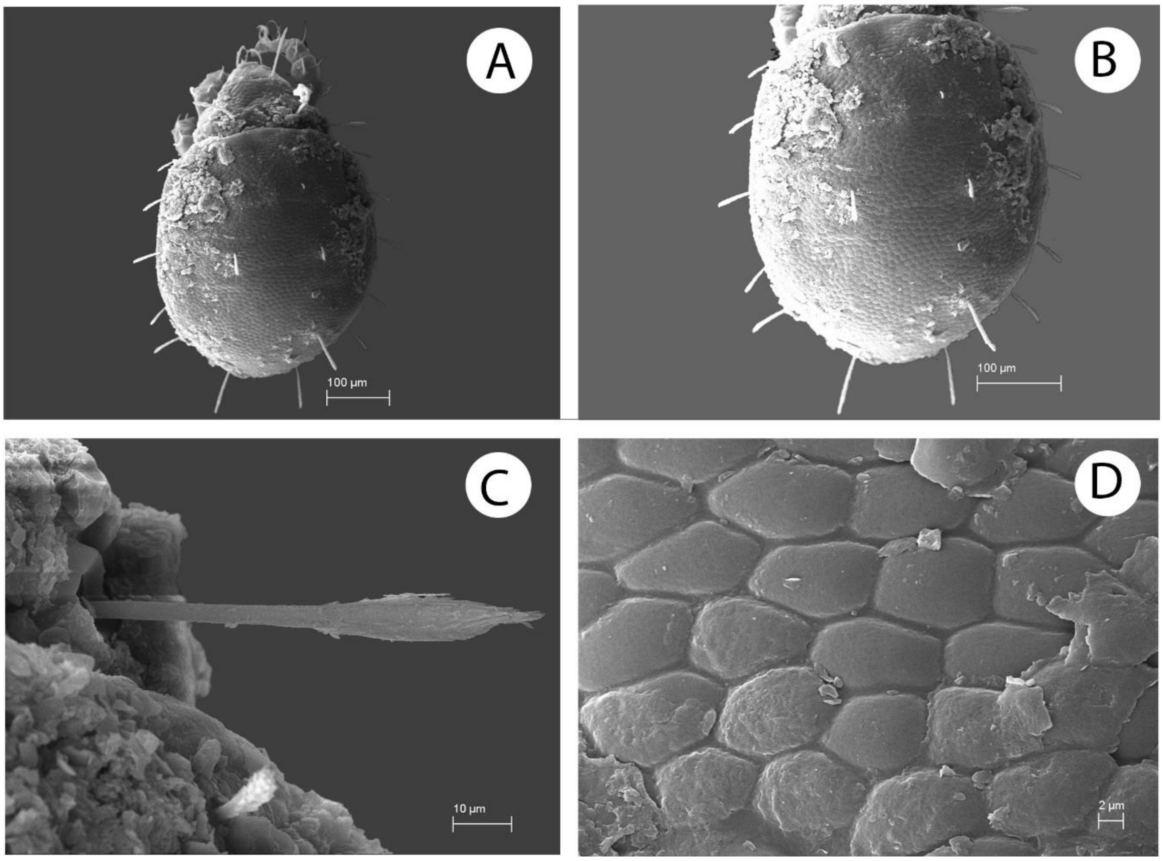


**Figure 2.** *Trhypochthonius silvestris europaeus* Weigmann and Raspotnig, 2009. **A.** Dorsal view, **B.** Notogaster, **C.** Sensillus, **D.** Pattern in central part of notogaster.

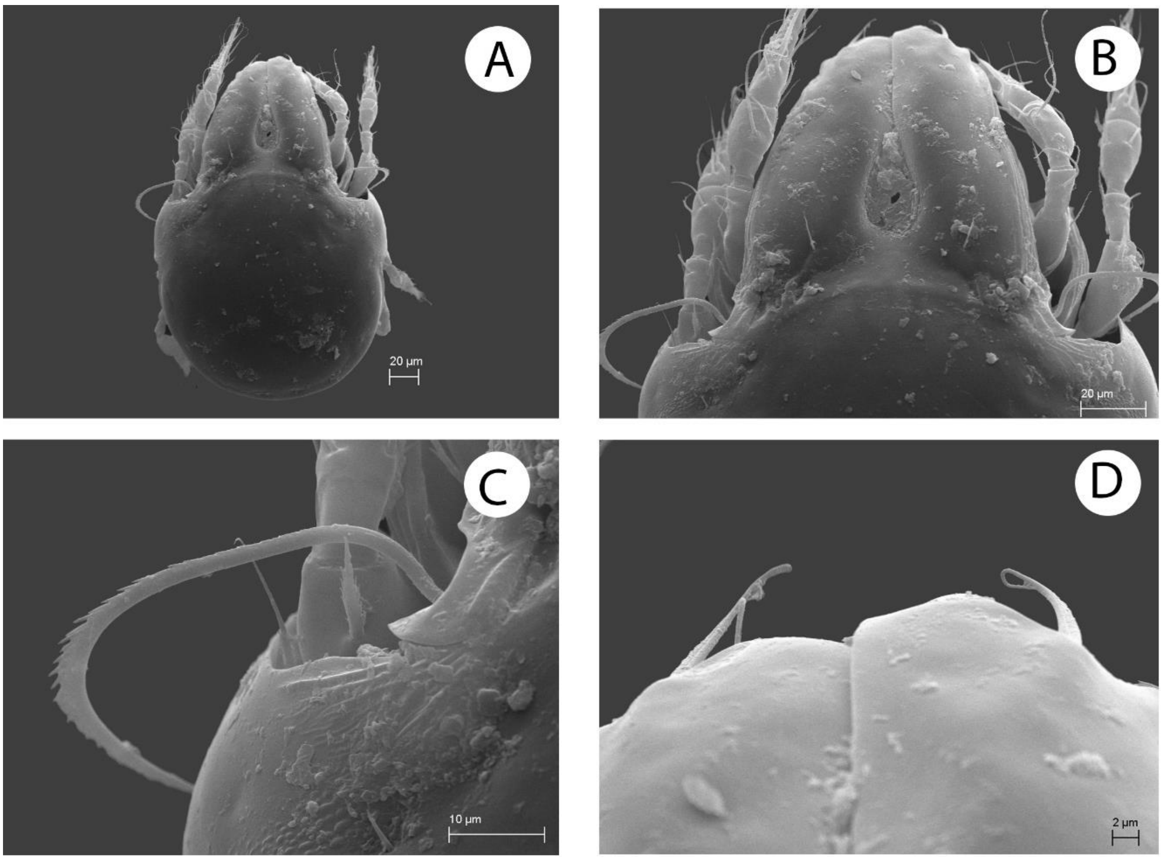


**Figure 3.** *Microzetes* (*M.*) *caucasicus* (Krivolutsky, 1967). **A.** Dorsal view, **B.** Prodorsum, **C.** Sensillus, **D.** Anterior region of lamella and lamellar setae.

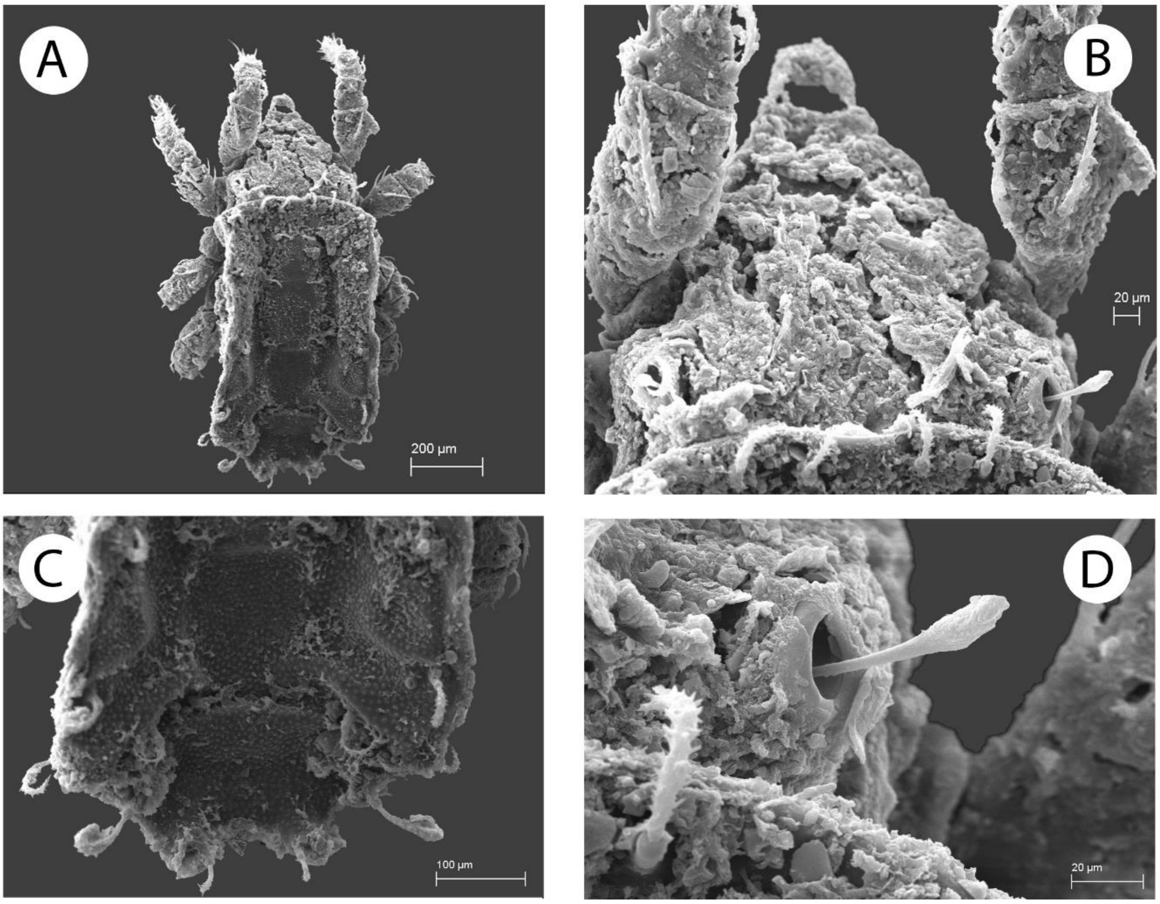

**Figure 4.** *Camisia biverrucata* (Koch, 1839). **A.** Dorsal view, **B.** Prodorsum, **C.** Posterior region of notogaster, **D.** Sensillus.

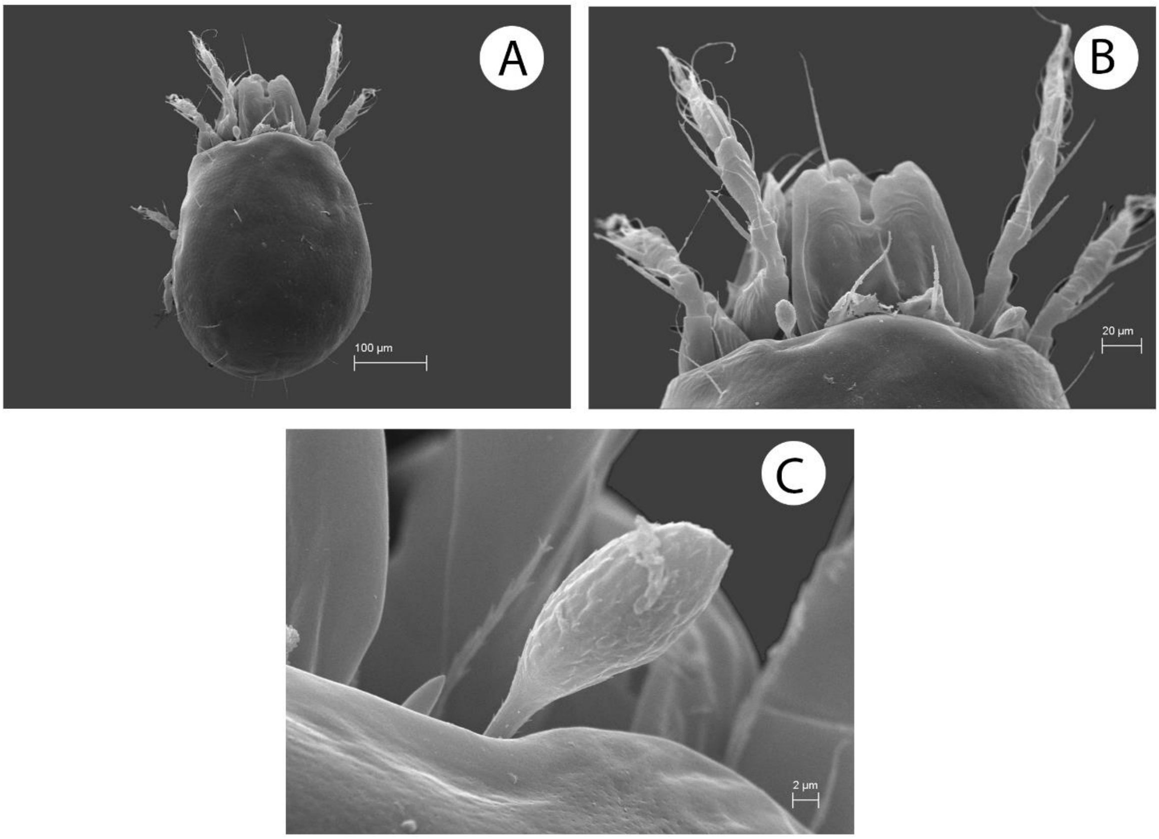

**Figure 5.** *Trichoribates* (*Latilamellobates*) *algarvensis* (Subías and Gil-Martín, 1990). **A.** Dorsal view, **B.** Prodorsum, **C.** Sensillus.

## DISCUSSION

*Trhypochthonius silvestris europaeus* Weigmann and Raspotnig, 2009

This subspecies is distributed in Central Europe (Austria, Germany, South Sweden) (Subías, 2004, updated 2024; Weigmann and Raspotnig, 2009). The body length of the type specimen is given as 540-620 by Weigmann and Raspotnig (2009). The Turkish specimens (544-608 x 360-400) are within the range of the species' known size. The other main characters of Turkish specimens match Weigmann and Raspotnig's (2009) original description. The holotype of *T. silvestris europaeus* was found in Austria in litter and moss in a Pinus stands. In Germany, it was collected from the same habitats (Weigmann and Raspotnig, 2009). We found it in low numbers in soil with grass.

*Microzetes* (*Microzetes*) *caucasicus* (Krivolutsky, 1967)

This species is distributed in Caucasus (Murvanidze and Mumladze, 2016). The body size of this species is given as 240-154 (Krivolutsky, 1967). The Turkish specimens (230-237 x 154-160) are smaller than the dimension the species' known size. The other main characters of Turkish specimens match the orginal description. It was found in mixed forest, 900 m a.s.l. at Krasnodar region located in the North Caucasus (Shtanchaeva et al., 2018). This species is known to inhabit humid forest soils and meadows (Murvanidze and Mumladze, 2016). We collected only few individuals from soil and litter in mixed forest.

*Camisia* (*Camisia*) *biverrucata* (Koch, 1839)

This species is distributed in Holarctic (frequent in Palearctic) and Nepal (Subías, 2004, updated 2024). The body length of the species is given as 1040-1150 by Weigmann (2006) and 930-1097 by Colloff (1993). The Turkish specimens (1052-1094 x 440-476) are within the range of the species' known size. The other main characters of the Turkish specimens match the descriptions given by the various authors (Colloff, 1993; Weigmann, 2006). *C. biverrucata* lives in drier meadows and in the area from the shrubland to the mountain pine zone (Weigmann, 2006). It is not common species, its ecology still remains unclear (Weigmann et al., 2015). We found it in soil and litter.

*Trichoribates* (*Latilamellobates*) *algarvensis* (Subías and Gil-Martín, 1990)

This species is distributed in Southwest Europe (Spain, Portugal) (Subías and Gil-Martín, 1990, 1995; Subías, 2004, updated 2024). The body length for the holotype of the species is given as 426 -273 by Subías and Gil-Martín (1990) and for Spanish specimens 450-470 x 295 by Subías and Gil-Martín (1995). The Turkish specimen (421 x 277) are within the range of the species' known size. The other main characters of the Turkish specimen match Subías and Gil-Martín's (1990) original descriptions. In Portugal, only one specimen of this species (holotype) was found on the ground of creeping bushes (Subías and Gil-Martín, 1990). We found only one specimen in soil with grass.

### Authors' contributions

**Ayşe Toluk:** Conceptualization, supervision, validation, writing-original draft, writing-review and editing. **Mehmet Taşkıran:** Investigation, validation, visualization, writing-original draft, writing-review and editing.

### Statement of ethics approval

Not applicable.


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### Conflict of interest

The authors declare that there are no conflicts of interest.

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RESEARCH NOTE

# A report on numerical variations in the dorso-central setae *pdx* of *Neophyllobius yunusi* Akyol and Koç (Trombidiformes: Camerobiidae)

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**ASBTRACT:** *Neophyllobius* Berlese is the largest genus of the family Camerobiidae Southcott, with about 140 species to date. In this study, the presence of numerical variations in setae *pdx* of *Neophyllobius yunusi* Akyol and Koç, known from Türkiye, has been demonstrated for the first time.

**Keywords:** Acari, anomaly, asymmetry, dorsal seta, morphology
**Zoobank:** https://zoobank.org/8603AF3A-55F9-4712-90BB-9B40B6009FB2

The Camerobiidae Southcott (Trombidiformes) is the second largest family in the superfamily Raphignathoidea after Stigmaeidae, and comprises more than 175 species within seven genera (Akyol and Koç, 2006; Akyol, 2020; Beron, 2020, 2022; Mirza et al., 2022; Escobar-Garcia et al., 2023, 2024). *Neophyllobius yunusi* Akyol and Koç was described from Afyonkarahisar and Kütahya provinces, Türkiye (Akyol and Koç, 2006; Doğan, 2019; Beron, 2020). It can be recognized by having setae *pdx* on prodorsum, dorsal setae with small denticles, tarsus IV with one midventral setae, femur I with 4 setae and femur II with 3 setae (Akyol and Koç, 2006; Uluçay and Koç, 2014; Mirza et al., 2022). The aim of this study is to demonstrate the existence of numerical variations in setae *pdx* of *Neophyllobius yunusi*.

Altogether 21 females and 1 protonymph of *Neophyllobius yunusi* were collected from litter and moss in the Karasu Valley, Türkiye, between May 2022 and April 2023, as part of an on-going study on mite biodiversity, and subsequently examined. Mite specimens were extracted with using Berlese-Tullgren funnels, cleared in 60% lactic acid and mounted in Hoyer's medium on microscopic slides as discussed in detail by Fan and Zhang (2005). Asymmetrical variations in the specimens were studied and photographed with the aid a Leica DM 4000B phase-contrast microscope.

Typically, *Neophyllobius yunusi* exhibits a single pair of *pdx* setae on the prodorsum; however, among the 22 examined mite specimens, 9% showed anomalies in *pdx*. In one female, the *pdx* on the left side was duplex (Fig. 1A), while a protonymph displayed a single duplex *pdx* (Fig. 1B). This is the first report on the numerical variations in *N. yunusi*.

In some species of *Neophyllobius* and *Tycherobius*, variations or anomalies in setal notation on the leg, and on the dorsal and ventral idiosoma have been documented by Akyol and Koç (2006), Koç and Akyol (2007), Paredes-León et al. (2016) and Zmudzinski (2020).

The number and shape of dorsal and leg setae can be used for species identification, and variations might be observed in different developmental stages or among different populations. Numerical variations in these setae can occur due to a variety of factors, including species differences, developmental stages, and environmental conditions (such as temperature, humidity, and diet) (Bingül et al., 2017). These variations that disrupt bilateral symmetry can be expressed as anomaly (Bingül et al., 2017, 2018).

*Neophyllobius ostovani* Khanjani and Ahmad Hoseini has a single (unpaired) *pdx* seta (Khanjani et al., 2014). Similarly, dorsal idiosoma of three species of another genus *Tycherobius* in Camerobiidae, namely: *T. virginiensis* (McGregor), *T. acicula* Fan and Walter, and *T. emadi* Khanjani, Hajizadeh, Ahmad Hoseini and Jalili, also have a single *pdx* seta (McGregor, 1950; Bolland, 1986; Fan and Walter, 2006; Khanjani et al., 2013).

As the number of dorsal setae in some genera of this family can vary, caution is required when identifying or describing new species on the basis of a few specimens, particularly if their distinctive characters are related to the setae.

## Authors' contributions

**Salih Doğan:** Conceptualization, project administration, funding acquisition, data curation, writing-original draft, writing-review and editing. **Qing-Hai Fan:** Validation, writing-original draft, writing-review and editing.

## Statement of ethics approval

Not applicable.

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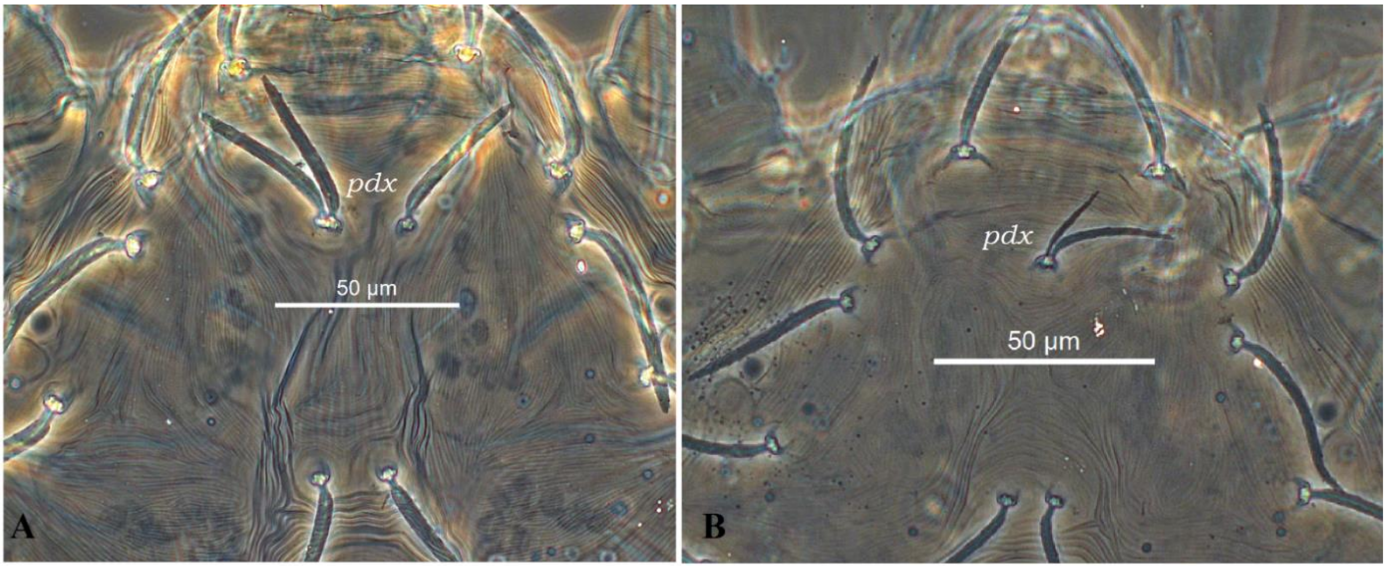


**Figure 1.** Numerical variations in setae *pdx* of *Neophyllobius yunusi* Akyol and Koç. **A.** Female, **B.** Protonymph.

## Conflict of interest

The authors confirm that there are no conflicts of interest.


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