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*Article*

# Associations of phoretic mites on bark beetles of the genus *Ips* in the Black Sea Mountains of Turkey

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**Abstract:** Phoretic mites use bark beetles for transportation to new, suitable habitats. Some phoretic mites act as predators and parasitoids of the bark beetles' immature stages, especially egg and early larval stages, and are potential agents for the biological control of scolytine forest pests. One of the most numerous and largest mite orders is Mesostigmata which live very frequently in relationships with other invertebrates. Many are found in association with various species of bark beetles. Here, a total of 41 specimens of different bark beetles of the genus *Ips (I. acuminatus, I. sexdentatus and I. typographus*) were studied for presence, species composition, and abundance of phoretic mites. The beetles were collected on dead wood and parts of tree bark of *Pinus nigra, P. slyvestris* and *Picea abies* in the Black Sea Mountains in Kastamonu and Artin Province of Turkey. A total of 9 mite species in 2 genera were found, including *Dendrolaelaps quadrisetus*, *Ereynetes* sp., *Histiostoma piceae*, *Paraleius* cf. *leontonychus*, *Pleuronectocaeleno barbara.*, *Proctolaelaps hystricoides*, *Schizostethus simulatrix*, *Trichouropoda lamellosa* and *Urobovella ipidis*. All species and genera are identified for the first time within Turkish fauna.

**Keywords:** Acari; *Ips sexdentatus*; *Ips acuminatus*; *Ips typographus*; *Pinus nigra*; *Pinus sylvestris; Picea abies*; Turkey

## 1. Introduction

Bark beetles are known to be associated with diverse guilds of arthropods and microorganisms, of which phoretic mites are among the best-known. Important characteristic called "phoresy" defines this interspecific relationship where one species acts as a host and the other acts as a "phoront", attaching itself to the host in order to disperse or migrate (Vissa and Hofstetter 2017). Phoretic mites use bark beetles for transportation to new suitable habitats and some species are able to impact bark beetle population through parasitism or predation (Moser 1975, Pernek et al. 2008, Hofstetter and Moser 2014, Hofstetter et al. 2015). Up to now, 270 mite species associated with different bark beetles were listed (Hofstetter et al. 2013; Hofstetter et al. 2015). It is of particular practical importance that some phoretic mites act as predators and parasitoids of the bark beetles' immature stages, especially egg and early larval stages. They are thus potential agents for the biological control of scolytine forest pests (Pernek et al. 2012, Hofstetter et al 2015). Interaction with antagonistic fungi associated with bark beetles could affect bark beetle survival and reproduction (Klepzig et al., 2001, Lombardero et al. 2003). Furthermore, mites facilitate the movement of microorganisms across trees (Hofstetter and Moser 2014).

One of the most numerous and largest mite orders is Mesostigmata. Most species are wild predators, parasites, or symbionts of mammals, birds, reptiles and arthropods (Walter *et al*. 2009). Although it is well known that they live very frequently in relationships with other invertebrates (Rosario and Hunter, 1988) and have associations with

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various species of bark beetles (Kiełczewski et al., 1983), in many regions, like the Turkish Black Sea basin, there is lack of knowledge about the species composition.

Turkish Black Sea basin is stretched from west to east along the southern part of the Black Sea. Mountainous landscape from the east and the Black Sea from the north, create a transitional climatic profile with precipitation between 500 and 1000 mm; rich flora with intact forests are characterized by the dominance of woody species such as *Fagus orientalis* Lipsky, *Quercus* sp., *Carpinus betulus* L., *Pinus nigra* Arn. (Zeydanli 2020). Starting from northeastern Black Sea coast (which is a part of tertiary Colchis refugia) towards the east, the climate gets drier supporting a wealth of habitat varieties and vegetation types (Williams et al. 2006). This landscape and habitat diversity is also reflected in soil animal communities which are also very high for any well-studied animal taxa (Schütt 2005). Forests are spread along transition zone of the Black sea and Küre mountain range and therefore share climate characteristics of both regions. Taşköprü forest covers 113.500 ha area, Daday forest occupies 63867 ha, Küre forest 73.693 ha area and Ilgaz Mountains 748 ha area. Küre forests belong to Küre National Park, which was created on 7th July 2000 and is known as one of the diversity hotspots of Turkey because of its 930 plant, 129 bird, 48 mammal, 8 reptile and 9 amphibian registered species. Ilgaz Mountains are the highest mountain massif in the Western Black Sea Region. The highest peak is Büyükhacat Hill, which is also the highest peak of the Western Black Sea with an altitude of 2587 m, and the second highest peak is Küçükhacat hill with 2546 m of an altitude (Anonymous 2014). Forests in Artvin region are spread between two different zones: Eastern Black Sea Climate Zone and Eastern Anatolia Climate Zone. Local forests consist of essential tree species such as *Picea orientalis, Fagus orientalis*, *Abies nordmanniana* subsp. *nordmanniana*, *Pinus silvestris*, *Castanea sativa*, *Alnus glutinosa subsp. barbata*, and *Quercus* spp. (Yüksek and Ölmez 2002).

One of the insect groups that led to damages in forests of the Turkish Black Sea basin are bark beetles, Scolytinae (Coleoptera: Curculionidae), together with many well-known species spectrum (Knížek 2011, Sarikaya and Avci 2009, Sarikaya and Knížek 2013). The widely distributed European spruce bark beetle, *Ips typographus* Linnaeus, is one of the most economically significant pests in the Palaearctic. Although it infests mainly spruce *(Picea* spp.), this beetle also occurs on other conifers, such as *Pinus* spp. and *Abies* spp. (Maslov 2010). *Ips sexdentatus* Börner, *Ips acuminatus* Gyllenhal and *Tomicus piniperda* Linnaeus are the most damaging bark beetles in Turkey forests. Especially the six-toothed pine bark beetle, *I. sexdentatus* causes serious economic losses in spruce (in particular *P. orientalis*) forests in Turkey. Previously, strenuous effort has been expended to control this pest. Pheromone traps, and mechanical and chemical control strategies have been used for a long time, resulting in huge financial cost, and this pest still causes serious economic losses in oriental spruce forests in Turkey (Yüksel *et al*., 2000).

It is little known about the phylogeny of most mite taxa, so extensive sampling is required (Hofstetter et al. 2015). The purpose of this paper is to list new records of phoresy by mites on bark beetles. The aim of this study was to identify phoretic mites associated with bark beetles in Ilgaz Mountains of Northern Turkey, in order to make the first list of species composition in this region.

## 2. Materials and Methods

### *2.1. Study area*

In Kastamonu region sampling was conducted on dead wood and parts of tree bark of *P. nigra*, *P. sylvestris* and *P. abies* in Taşköprü, Küre, Daday and Ilgaz forests between April–June 2018 and 2019. Dead wood and parts of tree bark of *P. nigra* and *P. sylvestris* were collected on 1.5 m height from the forest floor. In addition, several *P. abies* trunks

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were sampled from forest of Artvin which is located in the Eastern Black Sea Region (Figure 1). The mite species were collected on *I. sexdentatus* and *I. acuminatus* in Kastamonu forests and on *I. typographus* in Artvin forests.


Figure 1. Map of the study area with the points of data collection

*2.2. Sampling procedures, laboratory treatment and identification of phoretic mites*

All samples were placed in plastic bags, labelled and transported to the laboratory in refrigerators. The collected bark beetles were placed into vials containing 96% ethanol. Mites were extracted using Berlese-Tullgren funnels for one week and individuals were stored in 80% alcohol. The phoretic mites specimens found on bark beetles were collected by C. Cilbircioglu and sent to M. Pernek for determination. Voucher specimens (slides) of all mite species detected in this study are stored in the collections of the authors.

Interventionary studies involving animals or humans, and other studies that require ethical approval, must list the authority that provided approval and the corresponding ethical approval code.

## 3. Results

In total, 63 phoretic mites were extracted from 41 bark beetle adults in this study, belonging to different families: Digamasellidae, Ereynetidae, Hemileiidae, Histiostomatidae, Melicharidae, Celaenopsidae, Uropodidae and Urodinychidae. Nine species and 2 genera were recorded for the first time for the Turkish fauna (Table 1, Figure 2).

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Figure 2. Phoretic mites from Ips spp. in Artvin forests. (a) *Pleuronectocaeleno barbara,* (b) *Schizostethus simulatrix*, (c) *Paraleius cf. leontonychus*, (d) *Trichouropoda lamellose*, (e) *Ereynetes* sp., (f) *Histiostoma piceae*, (g) *Dendrolaelaps quadrisetus,* (h) *Proctolaelaps hystricoides,* (i) *Urobovella ipidis*

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The mites were located under the elytra (8%) and on the elytral declivity (27%), dorsal thorax (13%), ventral thorax (5%) and legs (7%). Of the 5 mites found in alcohol and lactophenol sediments, 92% were the same species as those attached to the beetles. A total of 9 mite species were documented. All of these species were previously known to be phoretic: *Dendrolaelaps quadrisetus* (Berlese), *Ereynetes* sp. (Fain), *Histiostoma piceae* (Scheucher), *Paraleius cf. leontonychus*, *Pleuronectocaeleno barbara* (Athias-Henriot), *Proctolaelaps hystricoides* (Lindquist and Hunter), *Schizostethus simulatrix* (Athias–Henriot), *Trichouropoda lamellosa* (Hirschmann) and *Urobovella ipidis* (Vitzthum). Mites were either phoretic as females (*Ereynetes* sp., *Pleuronectocaelleno barbara*, P. *Hystricoides*) or as deutonymphs (*D. quadrisetus, H. piceae*, *S. simulatrix*, *T. ipidis*, *T. lamellosa* and *U. ipidis*). The most frequently observed mite species was *Proctolaelaps hystricoides*, representing 34.9% of all specimens. *Schizostethus simulatrix* (19.0%), *Dendrolaelaps*

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*quadrisetus* (17.5%) and *Trichouropoda lamellosa* (15.9%) were common, whereas the other six species were rare.

Table 1. Abundance of phoretic mites on *Ips typographus*, *Ips sexdentatus* and *Ips acuminatus* collected in Northern Turkey

| Mite species and phoretic stage | Location on bark beetle | Total number of phoretic mites on BB | Number of mites in alcohol sediments | Number of mites in lactophenol sediments | Total number of mites | Percent of total mites found (n=63) |
|---|---|---|---|---|---|---|
| *Dendrolaelaps quadrisetus* Deutonymph | Under elytra of *Ips sexdentatus* Ventral abdomen of *Ips acuminatus* Ventral thorax and head of *Ips typographus* | 10 | - | 1 | 11 | 17.5 |
| *Ereynetes* sp. Female | Leg of *Ips acuminatus* | 1 | - | - | 1 | 1.6 |
| *Histiostoma piceae* Deutonymph | Under elytra of *Ips sexdentatus* | 1 | - | - | 1 | 1.6 |
| *Paraleius cf. leontonychus* | Galleries of BB | - | 1 | - | 1 | 1.6 |
| *Pleuronectocaeleno barbara* Female | All body of *Ips sexdentatus* | 1 | - | - | 1 | 1.6 |
| *Proctolaelaps hystricoides* Female | *Ips acuminatus* in galleries of BB | 20 | - | 2 | 22 | 34.9 |
| *Schizostethus simulatrix* Deutonymph | Elytral declivity of *Ips typographus* | 12 | - | - | 12 | 19.0 |
| *Triheuropoda ipidis* Deutonymph | Unknown Elytral declivi- | - | 1 | - | 1 | 1.6 |

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|---|---|---|---|---|---|---|
| *Trichouropoda lamellosa* Deutonymph | ty of *Ipstypographus* Dorsal thorax of *Ips sexdentatus* | 10 | - | - | 10 | 15.9 |
| *Urobovella ipidis* Deutonymph | Dorsal thorax of *Ips typographus* | 3 | - | - | 3 | 4.7 |
| | Total | 58 | 2 | 3 | 63 | 100.0 |

Order **Mesostigmata**
Family **Digamasellidae**
Genus **Dendrolaelaps** Halbert, 1915
***Dendrolaelaps quadrisetus*** **(**Berlese, 1920)
**Material.** Turkey, Black Sea Region, Kastamonu Province: Taşköprü Disctrict, Kapaklı forests (41°24N, 34°19E), 1203 m, on Pinus nigra L. (Pinaceae), 22.06.2019, 3 DN; Daday District, Çamkonak Forests (41°23N, 34°13E), 1494 m, on Pinus nigra L. (Pinaceae), 30.05.2018, 3 DN; Küre District, Masruf Forests (41°43N, 33°39 E), 1272 m, on Pinus nigra L. (Pinaceae), 30.05.2018, 2 DN; Black Sea Region, Artvin Province (41°11N, 41°48E), 708 m, on Picea abies (L.) Karst (Pinaceae), 24.05.2019, 3 DN (C. Cılbırcıoğlu).

Family **Melicharidae**
Genus ***Proctolaelaps*** Berlese, 1923
***Proctolaelaps hystricoides*** (Lindquist and Hunter, 1965)
**Material.** Turkey, Black Sea Region, Kastamonu Province: Küre District, Masruf Forests (41°43N, 33°39E), 1272 m, on Pinus nigra L. (Pinaceae), 30.05.2018, 22♀♀ (C. Cılbırcıoğlu).

Family **Melicharidae**
Genus ***Schizostethus*** Athias-Henriot 1982
***Schizostethus simulatrix*** (Athias–Henriot) 1982
**Material.** Turkey, Black Sea Region, Artin Province (41°11N, 41°48E), 708 m, on Picea abies (L.) Karst (Pinaceae), 24.05.2019, 12 DN (C. Cılbırcıoğlu).

Family **Uropodidae**
Genus ***Trichouropoda*** Berlese, 1916
***Trichouropoda lamellosa*** Hirschmann, 1972
**Material.** Turkey, Black Sea Region, Kastamonu Province: Küre District, Masruf Forests (41°43N, 33°39E), 1219 m, on Pinus nigra L. (Pinaceae), 17.07.2019,4 DN; Kastamonu Province: Daday District, Çamkonak Forests (41°23N, 33°13E), 1494 m, on Pinus nigra L. (Pinaceae), 30.05.2018, 2 DN; Artin Province, (41°11N, 41°48E), 708 m, on Picea abies (L.) Karst (Pinaceae), 24.05.2019, 4 DN.

Family **Urodinychidae**
Genus ***Urobovella*** Berlese, 1903
***Urobovella ipidis*** (Vitzthum, 1923)
**Material.** Turkey, Black Sea Region, Kastamonu Province: Küre District, Masruf Forests (41°43N, 33°39E), 1272 m, on Pinus nigra L. (Pinaceae), 17.07.2019, 3 DN.

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Family Caelenopsidae
Genus ***Pleuronectocaeleno***
***Pleuronectocaeleno barbara*** (Athias-Henriot, 1959)
**Material.** Turkey, Black Sea Region, Kastamonu Province: Taşköprü District: Kapaklı Village Forest Area, (41°24'N, 34°19'E), 1312 m, on Pinus nigra L. (Pinaceae), 01.07.2019, 1♀.

Order **Astigmata**
Family ***Histiostomatidae***
Genus ***Histiostoma*** Kramer, 1876
***Histiostoma piceae*** **(**Scheucher, 1957)
**Material.** Turkey, Black Sea Region, Kastamonu Province: Ilgaz Mountains, (41°22'N, 34°32'E), 1407 m, on Pinus sylvestris L. (Pinaceae), 20.04.2018, 1 DN.

Order **Oribatida**
Family ***Hemileiidae***
Genus ***Paraleius*** Travé, 1960
***Paraleius cf. leontonychus*** (Berlese, 1910)
**Material.** Turkey, Black Sea Region, Kastamonu Province: Taşköprü District, Kapaklı Forests, (41°25'N, 34°18'E), 917 m, on Pinus nigra L. (Pinaceae), 21.07.2019, 1 mite.

Order **Trombidiformes**
Family ***Ereynetidae***
Genus ***Ereynetes*** **sp.** Fain, 1964
**Material.** Turkey, Black Sea Region, Kastamonu Province: Küre District, Masruf Forests (41°43N, 33°39 E), 1272 m, on Pinus sylvestris L. (Pinaceae), 30.05.2018, 1♀.

## 4. Discussion

The ecological roles of phoretic mites associated with bark beetles are generally poorly known. It is assumed that their biology and ecology is diverse (Klepzig et al. 2001; Lombardero et al. 2003, Pernek et al. 2008) and they can be beneficial or detrimental to beetles (Vissa and Hofstetter 2017). They may be filter feeder of bacteria and yeasts (Oconnor 1984), prey on nematodes (Kinn 1967, 1987), or they could prey on subcortical arthropods, even on small mites, eggs and immature stages of larger arthropods, i.e. *S. simulatrix* and *E. scutulis* could have some potential for biological control of bark beetle pests (Pernek et al. 2008). *Dendrolaelaps quadrisetus* prey on nematodes and may have an important role in controlling of bark beetle populations (Kinn 1967, 1987). In Khaustov et al. (2018) feeding on the eggs of *Ips typographus* was observed. Specimens found in this research were collected under elytra of *Ips sexdentatus*, ventral abdomen of *Ips acuminatus* and ventral thorax and head of *Ips typographus* in *Pinus nigra* and *Picea abies*. *Histiostoma piceae* was also collected under the elytra of *Ips sexdentatus* in *Pinus sylvestris*, and like most members of this genus, this species may occur in liquid, "soupy" substrates, and may be a filter feeder of bacteria and yeasts (Oconnor 1984).

Species *Proctolaelaps hystricoides* that can feed on fungal spores (Pernek et al. 2008) was collected on galleries of *Ips acuminatus* in *Pinus nigra*, and was found in the highest abundance of all species in this study (34.9%).

*Schizostethus simulatrix* may prey on subcortical arthropods, as it is a member of the predatory mite family Parasitidae (Moser 1975, Pernek et al. 2008). It was collected on elytral declivity of *Ips typographus* in *Picea abies* and was second most frequently found species in this study (19%).

*Trichouropoda lamellosa* was collected on dorsal thorax of *Ips sexdentatus* and elytral declivity of *Ips typographus* in *Pinus nigra* and *Picea abies*. This species usually preys on nematodes (Kinn 1967, 1987). No records exist about the feeding habits of *Urobovella ipidis.* Here, this species was collected on dorsal thorax of *Ips typographus* in *Pinus nigra*.

*Paraleius cf. leontonychus* as a member of the oribatids is a detritivore species (Jacot 1934; Walter and Proctor 1999). One specimen was collected from galleries of bark beetle *Ips acuminatus* in *Pinus nigra.*

Species of the genus *Ereynetes* sp. are small, soft bodied prostigmatic predator mites that live on moss, lichens, litter, bat guano, in association with nests of scarabeids, birds and mammals, in decomposing wood, in coleopteran galleries, and under bark (Hunter 1964; André & Fain, 2000; OConnor & Klimov, 2004). Some species may feed on small mites, eggs and immature stages of larger arthropods or on nematodes (Walter and Proctor 1999). One specimen of this genus found in this research was collected from the leg of *Ips acuminatus* in *Pinus sylvestris*. Pleuronectocaeleno *barbara* was collected on all body of *I. sexdentatus* in *Pinus nigra* and was identified only to the genus level. Some of this species may also feed on nematodes (Kinn 1971). All phoretic mite species and genera found and identified in this study are new records for the Turkish phoretic fauna. Further field and laboratory studies are required to precisely assess the feeding habits of the phoretic mites of *Ips* spp., and their potential use as biocontrol agents against bark beetles.

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