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Original article (Orijinal araştırma)

Oribatid mite fauna of Kocaeli City Forest (Kocaeli, Turkey)¹

Kocaeli Kent Ormanı (Kocaeli, Türkiye) Oribatid akar faunası

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Abstract

In this study, the oribatid mites collected from Kocaeli City Forest (Kocaeli, Turkey) between 2016-2017 were examined faunistically. In total 60 samples were collected from soil and litter. Berlese-Tullgren funnels were used for extraction of oribatid mites. Twenty-two species belonging to families Amerobelbidae, Astegistidae, Chamobatidae, Eniochthoniidae, Eremaeidae, Epilohmanniidae, Galumnidae, Gymnodamaeidae, Liacaridae, Micreremidae, Nanhermanniidae, Neoliodidae, Oppiidae, Oribatulidae, Parakalummidae, Protoribatidae, Scheloribatidae and Tectocepheidae were detected. One family (Parakalummidae), two genera (*Cultroribula* and *Masthermannia*) and four species [*Allogalumna integer* (Berlese, 1904), *Cultroribula bicultrata* (Berlese, 1905), *Masthermannia mammillaris* (Berlese, 1904), *Neoribates (N.) bulanovae* Grishina, 2009] are recorded for the first time in Turkey. Scanning electron microscopy images and geographical distributions of each species are provided.

Keywords: fauna, Kocaeli City Forest, new records, Oribatida, soil biodiversity

Öz

Bu çalışmada, 2016-2017 yılları arasında Kocaeli Kent Ormanı'ndan toplanan oribatid akarlar faunistik bakımdan incelenmiştir. Toplam 60 örnek toprak ve döküntüden toplanmıştır. Oribatid akarların ayıklanması için Berlese-Tullgren huni düzeneği kullanılmıştır. Amerobelbidae, Astegistidae, Chamobatidae, Eniochthoniidae, Eremaeidae, Epilohmanniidae, Galumnidae, Gymnodamaeidae, Liacaridae, Micreremidae, Nanhermanniidae, Neoliodidae, Oppiidae, Oribatulidae, Parakalummidae, Protoribatidae, Scheloribatidae ve Tectocepheidae familyalarına ait 22 tür teşhis edilmiştir. Bir familya (Parakalummidae), iki cins (*Cultroribula* ve *Masthermannia*) ve dört tür [*Allogalumna integer* (Berlese, 1904), *Cultroribula bicultrata* (Berlese, 1905), *Masthermannia mammillaris* (Berlese, 1904), *Neoribates (N.) bulanovae* Grishina, 2009] Türkiye'de ilk kez kaydedilmiştir. Her bir türün morfolojik karakterlerine ait tarama elektron mikroskobu görüntüleri ve coğrafi dağılımları verilmiştir.

Anahtar sözcükler: fauna, Kocaeli Kent Ormanı, yeni kayıtlar, Oribatida, toprak biyoçeşitliliği

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Introduction

Oribatid mites are major constituents of soil biological diversity and they act as engineers of soil structure and indicators of soil health (Smol et al., 2001; Douglas, 2007). Oribatid mites tend to be concentrated in the surface litter layers of mineral soils. They are important due to their ecological roles such as fragmentation of organic materials, physical and chemical changes of organic substances by digestion and helping the distribution of bacterial and fungal spores (Norton & Behan-Pelletier, 2009; Sevimli & Baran, 2016). They consume different kinds of food such as living or dead parts of plants or fungal and bacterial microbes inhabiting in the litter, and the remains of other soil inhabitants (Behan & Hill 1978; Moore et al., 1988).

The life cycle of oribatids can take up to 7 years in extreme habitats but in boreal to temperate regions usually it takes 1 or 2 years, and they are considered K-strategists because of their life history characteristics (Sovik & Leinaas, 2003; Lindo & Visser, 2004; John et al., 2006; Norton & Behan-Pelletier, 2009).

There are nearly 11,000 known oribatid mite species in the world (Subías, 2018). About 250 species have been recorded in Turkey (Özkan et al., 1988, 1994; Erman et al., 2007; Bezci et al., 2018). Research on the oribatid mites of Turkey has been associated with specific regions of the country. Kocaeli is one of richest provinces of Turkey in terms of forest assets (44%), but there has been only one investigation of oribatid fauna in this province (Baran & Bilici, 2017). The aim of this study was to make contribution to the knowledge of the oribatid mite fauna of Turkey, which is currently quite limited.

Material and Method

The study area and sampling

Soil and litter samples were collected from Kocaeli City Forest (Figure 1) between December 2016 and November 2017 at five different stations (Table 1), every month between 12.00 and 15.00 h. Soil cores of 20 cm in diameter and about 10 cm depth was taken from the surface layer of soil. Each sample was placed in a labeled bag for examination in the laboratory. Samples were placed in Berlese-Tullgren funnels for about 7 d. The oribatid mites preserved in 70% ethanol bottles under the funnels were removed by pipette and needle under the stereomicroscope. Specimens were placed in lactic acid in hollow slides for examination by light microscopy.

Table 1. Details of collection sites

Station code	Elevation (m)	Coordinates
KKO1.1-12	408 m	40°49'51.88" N, 29°54'45.36" E
KKO2.1-12	412 m	40°49'50.72" N, 29°54'43.11" E
KKO3.1-12	412 m	40°49'50.25" N, 29°54'41.89" E
KKO4.1-12	419 m	40°49'49.24" N, 29°54'42.46" E
KKO5.1-12	416 m	40°49'50.05" N, 29°54'43.08" E



Figure 1. Map of the study area (Anonymous, 2018; Holt et al., 2013).

Scanning electron microscopy

Specimens for identification were examined in the scanning electron microscope. Specimens were cleaned for 12 h in soil cleaning detergent and placed in stubs. After the stubs were covered with gold in Quorum SC7620 Sputter Coater (Quorum Technologies, Newhaven, UK) at low voltage 5-15 kV according to size of specimens. The images were taken with a Philips XL 30 SFEG scanning electron microscope (FEI, Eindhoven, Netherlands).

Terminology

Terminology and taxa identification were according to Balogh & Balogh (1992), Weigmann (2006) and Norton & Behan-Pelletier (2009).

Results and Discussion

Twenty-two species belonging to 18 families of oribatid mites from Kocaeli City Forest (Kocaeli, Turkey) were determined. The diagnostic features for species that are new records for Turkey are detailed below.

Nanhermanniidae Sellnick, 1928

Masthermannia mamillaris (Berlese, 1904)

Measurements. Average body length 389 µm and body width 177 µm (n = 2).

Diagnostic characters: Figure 2. Interlamellar, lamellar and notogastral setae T shaped, extremely long and flagellate. Notogaster with foveolate. Sensillus long, setiform and ciliate. Nine pairs of genital setae.

Material examined. KKO1.5, 2 specimens.

Distribution in Turkey. New genus record for Turkey.

General distribution. Pantropical and subtropical (Subías, 2018).

Remarks. This is the first record of genus *Masthermannia* for the Turkish fauna. This genus contains 10 species (Subías, 2018). This species is differentiated from all the other species of the genus by having long, setiform sensillus. The body length of this species is described as between 400-485 µm (Berlese, 1913; van der Hammen, 1959; Balogh & Mahunka, 1983; Weigmann, 2006) and the length of our specimen was close to the previously published dimensions of the species. In Europe this species reported from warm climates (Weigmann, 2006).

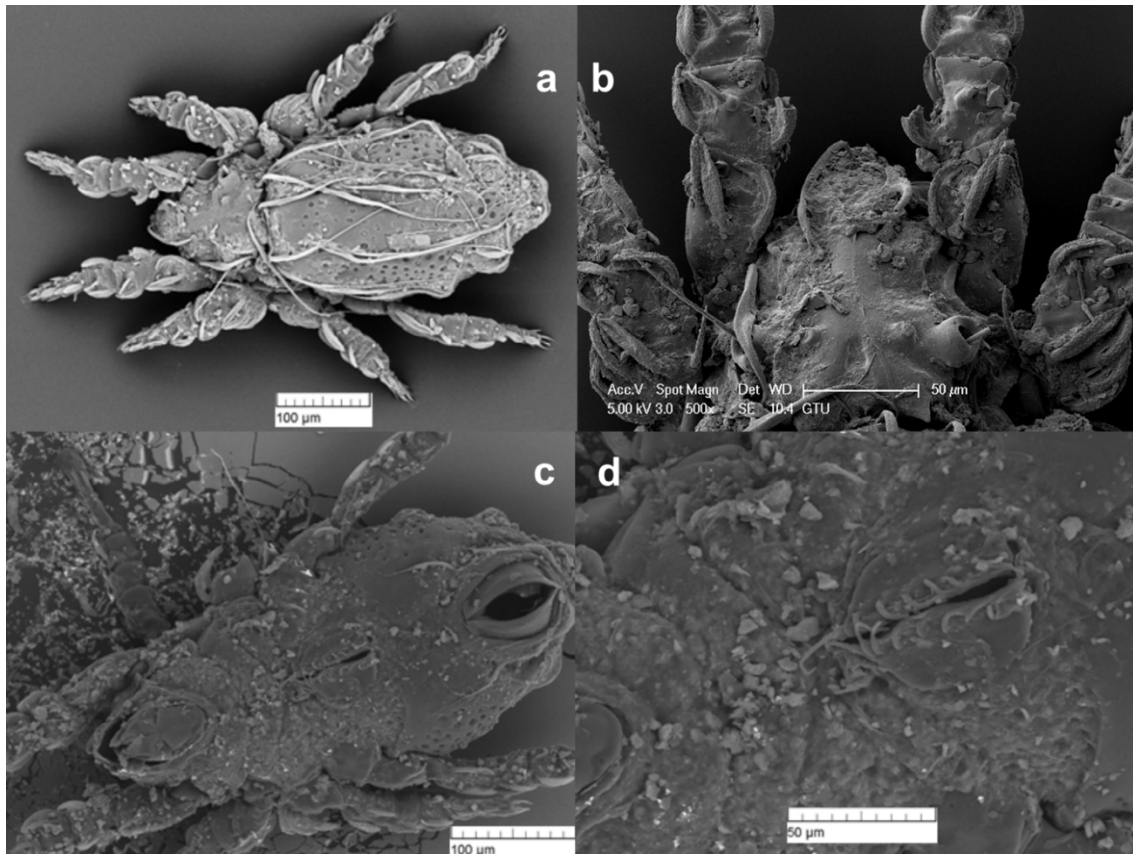


Figure 2. SEM images of *Masthermannia mammillaris*: a) dorsal view, b) prodorsum, c) ventral view and d) genital plate.

Astegistidae Balogh, 1961

***Cultroribula bicultrata* (Berlese, 1905)**

Measurements. Average body length 243 µm and body width 135 µm (n = 7).

Diagnostic characters. Figure 3. Rostrum with three very deep incisions. Legs with one claw. Interlamellar seta short and thin. Lamellar cuspis long and thin. Sensillus fusiform with long peduncle. Ten pairs of thin, setiform and short notogastral setae. Dorsal and ventral surface is smooth. Six pairs of genital setae and two pairs of anal setae present.

Material examined. KKO1.12, 5 specimens and KKO5.8, 2 specimens.

Distribution in Turkey. New family record for Turkey.

General distribution. Holarctic region (frequently Palearctic) (Subías, 2018).

Remarks. This is the first record of the genus *Cultroribula* for the Turkish fauna. *Cultroribula bicultrata* vary from the other species of genus by prolonged rostrum with long distal incisions. The body length of this species is described as between 225-250 μm (Bernini, 1969; Ghilarov & Krivolutsky 1975; Jacot, 1939; Balogh, 1943; Evans, 1952; Krivolutsky, 1962). Average body length of the Turkish specimens (243 μm) was in the range of the previously published dimensions for this species. This species has been reported from organic layers of forest soils (Weigmann, 2006).

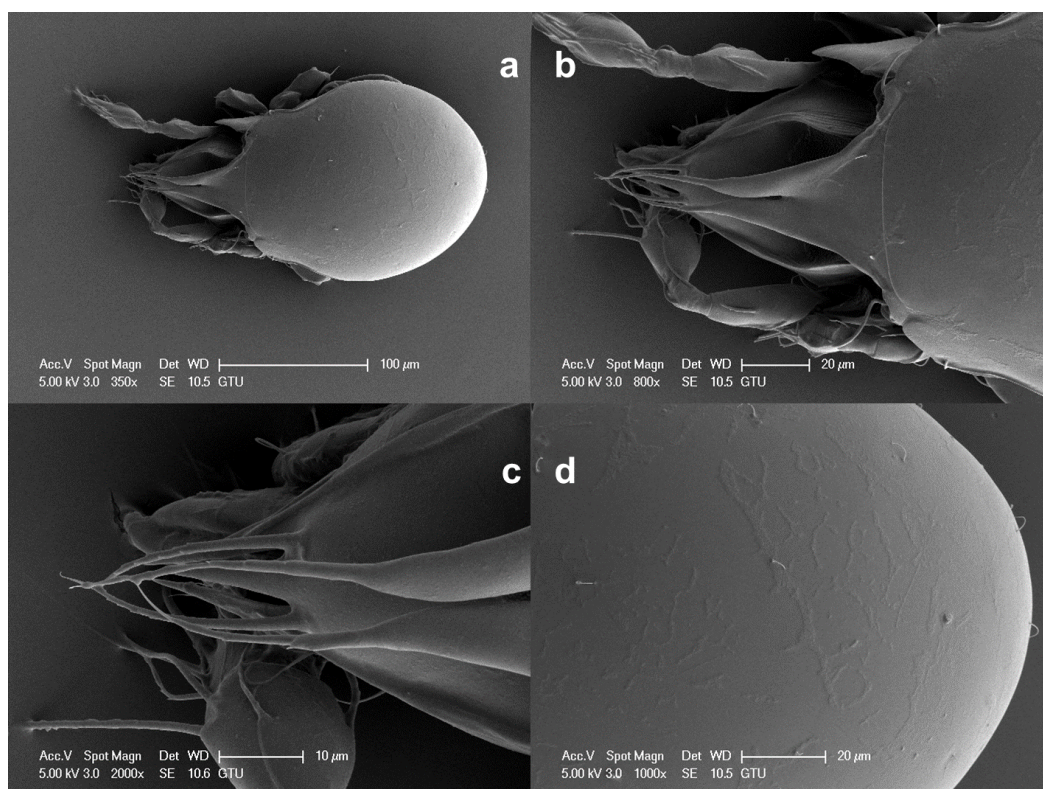


Figure 3. SEM images of *Cultroribula bicultrata* : a) dorsal view, b) prodorsum, c) rostrum and d) notogastral setae.

Parakalummidae Grandjean, 1936

Neoribates (N.) bulanovae Grishina, 2009

Measurements. Average body length 894 μm and body width 705 μm (n = 6).

Diagnostic characters. Figure 4. Ventral and dorsal sculpture smooth. Interlamellar seta bigger than lamellar and rostral seta. Rostral seta shorter than lamellar seta. Dorsosejugal suture oval, not distinct. Pteromorphs rounded, close to oval. Sensillus setiform and long. Five pairs of genital setae with thin and barbs. Large oribatids.

Material examined. KKO1.8, 3 specimens, KKO1.8, 1 specimen, KKO1.11, 1 specimen and KKO4.12, 1 specimen.

Distribution in Turkey. New record for Turkey.

General distribution. East Mediterranean (Subías, 2018).

Remarks. This is the first record of the family Parakalummidae for the Turkish fauna. *Neoribates (N.) bulanovae* differs from the other known species by larger size, rounded body shape and setiform sensillus. The body length of this species was described as 830-904 μm by Grishina & Vladimirova (2009). Average

body length of the Turkish specimens (894 μm) was in the range of the previously published dimensions of the species. *Neoribates (N.) bulanovae* was previously found in beech-oak forest in Ukraine (Grishina & Vladimirova, 2009). Our specimens were collected from soil under beech in a mixed forest.

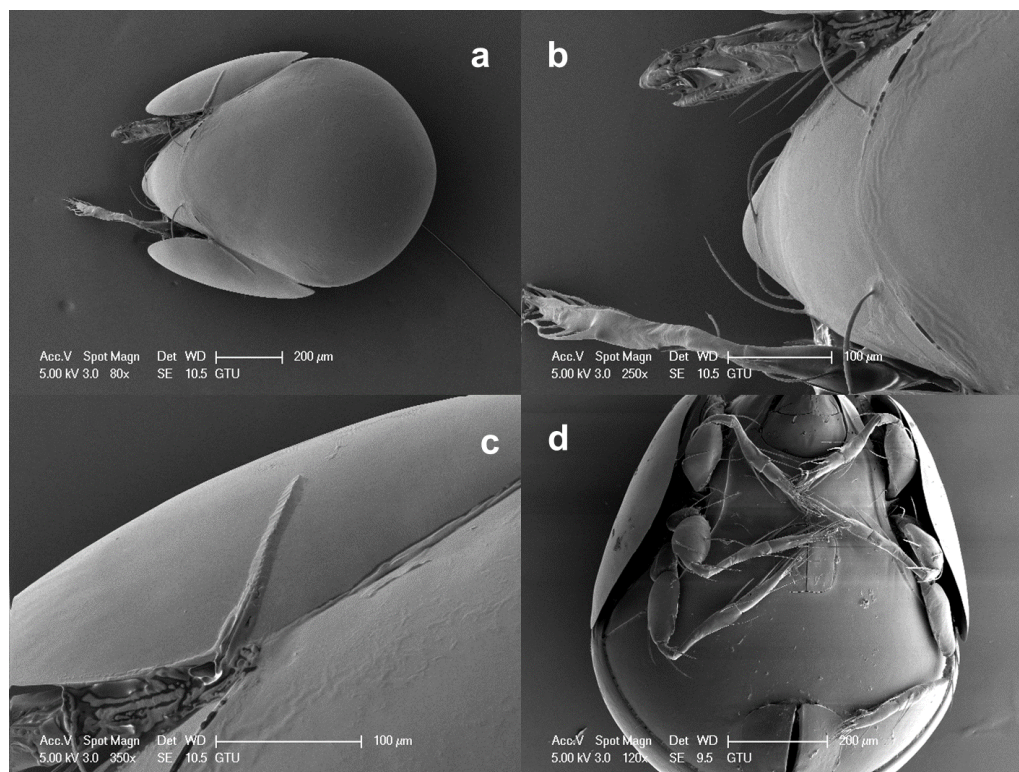


Figure 4. SEM images of *Neoribates (N.) bulanovae*: a) dorsal view, b) prodorsum, c) sensillus and d) ventral view.

Galumnidae Jacot, 1925

Allogalumna integer (Berlese, 1904)

Measurements. Average body length 442 μm and body width 319 μm (n = 10).

Diagnostic characters. Figure 5. Sensillus with dilated head and lanceolate. Dorsosejugal suture medially broken. Dorsal and ventral surfaces are smooth. Rostral seta smooth. Interlamellar seta developed and long. Aa oval. Legs with three claws.

Material examined. KKO1.1-12 81 specimens, KKO2.3, 6 specimens, KKO2.4, 1 specimen, KKO2.5 21 specimens, KKO2.6, 10 specimens, KKO2.7, 2 specimens, KKO2.8, 3 specimens, KKO2.9, 17 specimens, KKO2.10, 28 specimens, KKO2.11, 10 specimens, KKO2.12, 7 specimens, KKO3.1, 3 specimens, KKO3.4, 6 specimens, KKO3.5, 12 specimens, KKO3.6, 1 specimen, KKO3.7, 1 specimen, KKO3.8, 1 specimen, KKO3.9, 2 specimens, KKO3.10, 5 specimens, KKO3.11, 12 specimens, KKO3.12, 14 specimens, KKO4.1, 1 specimen, KKO4.4, 5 specimen, KKO4.5, 60 specimens, KKO4.6, 9 specimens, KKO4.7, 24 specimens, KKO4.8, 30 specimens, KKO4.9, 8 specimens, KKO4.10, 16 specimens, KKO4.11, 9 specimens, KKO4.12, 9 specimens, KKO5.2, 1 specimen, KKO5.4, 18 specimens, KKO5.5, 31 specimens, KKO5.7, 20 specimens, KKO5.8, 10 specimens, KKO5.9, 13 specimens, KKO5.10, 25 specimens, KKO5.11, 6 specimens and KKO5.12, 51 specimens.

Distribution in Turkey. New record for Turkey.

General distribution. Centromeridional Europe (Subías, 2018).

Remarks. *Allogalumna* is known as cosmopolitan genus (Subías, 2018). Previously, *Allogalumna turkeyensis* Grobler, Bayram & Cobanoğlu, 2004 (Grobler et al., 2004) was the only member of this genus previously recorded in Turkey. *Allogalumna integer* is similar to *Allogalumna iranica* Akrami, 2015 but it differs with ciliated lamellar seta and sensillus with dilated head (Akrami, 2015). The body length of this species was described as 440-600 μm (Berlese, 1904; Mihelcic, 1957). Average body length of the Turkish specimens (442 μm) was in the range of the previously published dimensions of the species. This species reported near ant nests (Berlese, 1904).

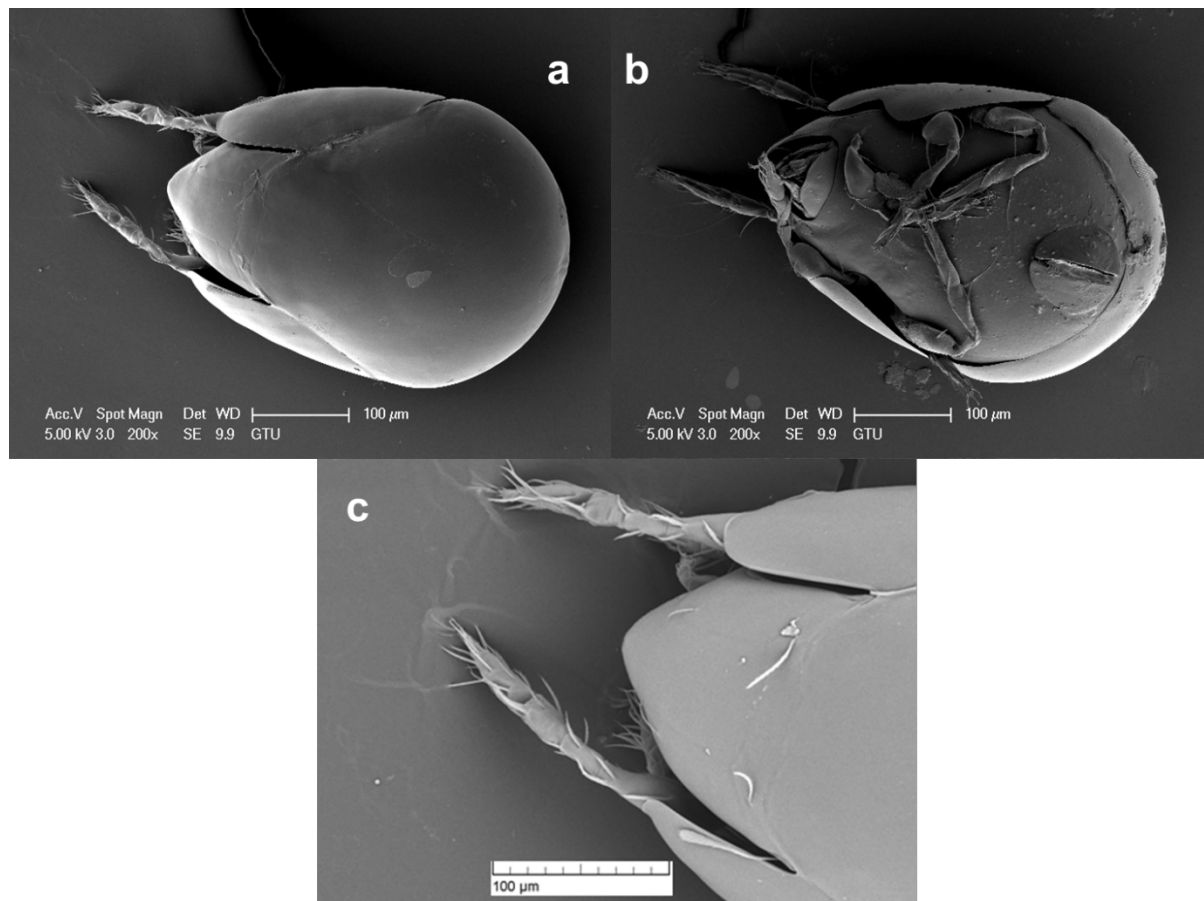


Figure 5. SEM images of *Allogalumna integer*: a) dorsal view, b) ventral view and c) prodorsum.

Species previously known in Turkey

Eniochthoniidae Grandjean, 1947

Hypochthoniella minutissima (Berlese, 1903) (Figure 6a)

Measurements. Body length 362 μm and body width 178 μm .

Material examined. KKO1.1-12 36 specimens.

Distribution in Turkey. Bolu (Toluk et al., 2017).

General distribution. Cosmopolitan (Subías, 2018).

Epilohmanniidae Oudemans, 1923

***Epilohmannia* (E.) *cylindrica* (Berlese, 1904) (Figure 6b)**

Measurements. Body length 431 µm and body width 159 µm.

Material examined. KKO2.1-12 1 specimen, KKO3.1-12 7 specimens, KKO4.1-12 2 specimens, and KKO5.1-12 1 specimen.

Distribution in Turkey. Erzurum, Konya, Kayseri and Sakarya (Ayyıldız, 1988a; Dik et al., 1999; Toluk & Ayyıldız, 2008a; Baran et al., 2015).

General distribution. Cosmopolitan (Subías, 2018).

***Epilohmannia* (E.) *imreorum* Bayoumi & Mahunka, 1976 (Figure 6c)**

Measurements. Body length 698 µm and body width 291 µm.

Material examined. KKO1.1-12 4 specimens and KKO4.1-12 1 specimen.

Distribution in Turkey. Sakarya (Baran et al., 2015).

General distribution. Mediterranean (Subías, 2018).

Nanhermanniidae Sellnick, 1928

***Nanhermannia* (N.) *nana* (Nicolet, 1855) (Figure 6d)**

Measurements. Body length 545 µm and body width 245 µm.

Material examined. KKO4.1-12 2 specimens.

Distribution in Turkey. Samsun and Düzce (Ayyıldız et al., 1996; Sarial & Baran, 2013).

General distribution. Semicosmopolitan (Subías, 2018).

Neoliodidae Sellnick, 1928

***Platylodes* *doderleini* (Berlese, 1883) (Figure 6e)**

Measurements. Body length 1095 µm and body width 553 µm.

Material examined. KKO4.1-12 2 specimens.

Distribution in Turkey. Çorum (Per, 2016).

General distribution. Southern Palearctic (Subías, 2018).

Gymnodamaeidae Grandjean, 1954

***Gymnodamaeus* *barbarossa* Weigmann, 2006 (Figure 6f)**

Measurements. Body length 525 µm and body width, 27 µm.

Material examined. KKO1.1-12 10 specimens, KKO2.1-12 89 specimens, KKO3.1-12 64 specimens, KKO4.1-12 8 specimens and KKO5.1-12 5 specimens.

Distribution in Turkey. Bolu (Toluk & Ayyıldız, 2014).

General distribution. Centromeridional Europe (Subías, 2018).

Liacaridae Sellnick, 1928

***Liacarus* (L.) *brevilamellatus* Mihalčič, 1955 (Figure 6g)**

Measurements. Body length 568 µm and body width 312 µm.

Material examined. KKO1.1-12 10 specimens, KKO2.1-12 4 specimens, KKO4.1-12 11 specimens, and KKO5.1-12 5 specimens.

Distribution in Turkey. Erzurum (Ocak et al., 2007; Akman et al., 2018).

General distribution. Southern Palearctic (Subías, 2018).

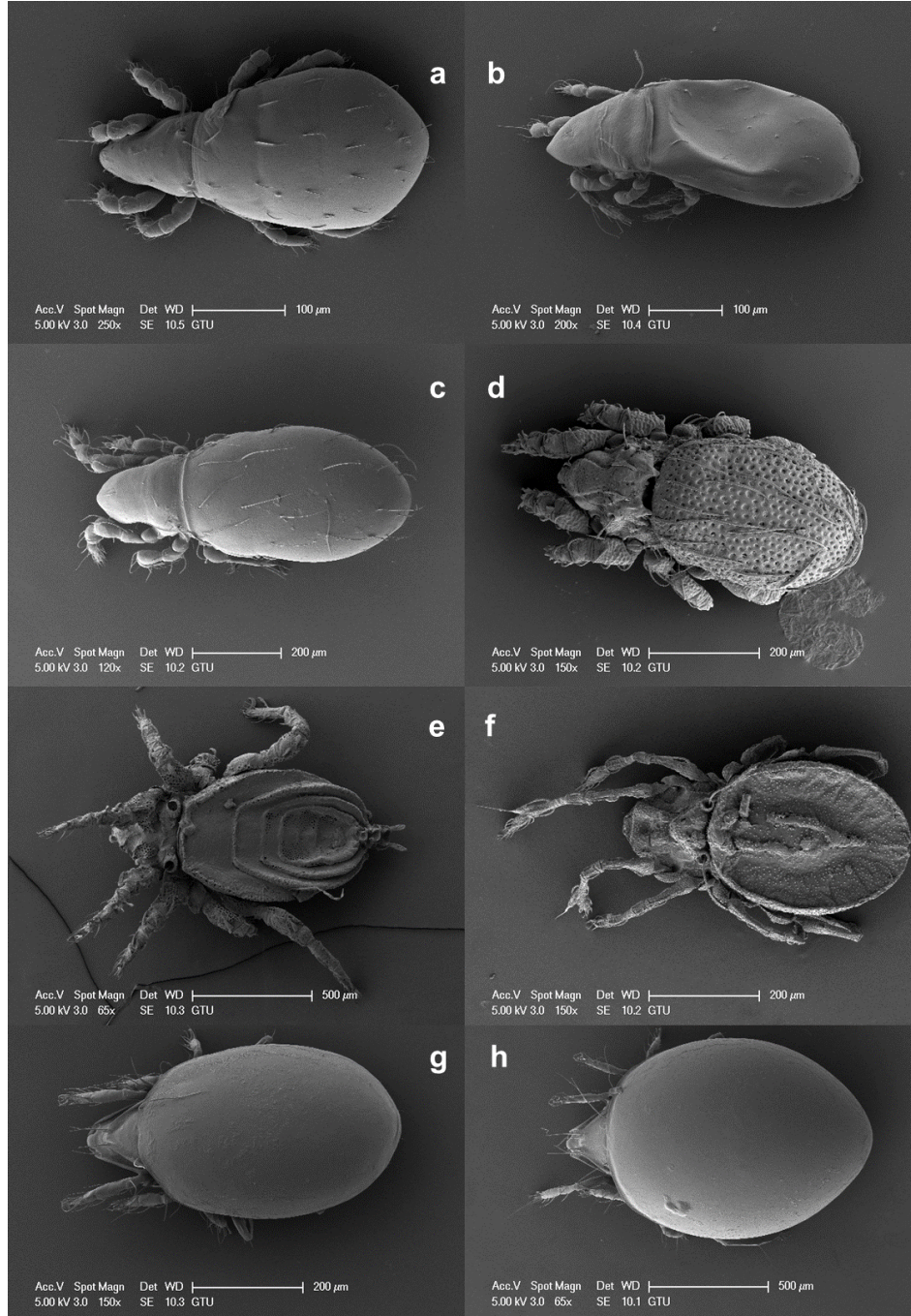


Figure 6. SEM images of a) *Hypochthoniella minutissima*, b) *Epilohmannia (E.) cylindrica*, c) *Epilohmannia (E.) imreorum*, d) *Nanhermannia (N.) nana*, e) *Platyliodes dodderleini*, f) *Gymnodamaeus barbarossa*, g) *Liacarus (L.) brevilamellatus* and h) *Liacarus (L.) coracinus*.

***Li acarus (L.) coracinus* (Koch, 1841) (Figure 6h)**

Measurements. Body length 1285 µm and body width 814 µm.

Material examined. KKO1.1-12 12 specimens, KKO2.1-12 9 specimens, KKO3.1-12 10 specimens, KKO4.1-12 9 specimens and KKO5.1-12 15 specimens.

Distribution in Turkey. Giresun, Mersin, Ordu and Samsun, Trabzon (Grobler et al., 2003).

General distribution. Palearctic region (Subías, 2018).

Eremaeidae Oudemans, 1900

***Eremaeus hepaticus cordiformis* Grandjean, 1934 (Figure 7a)**

Measurements. Body length 631 µm and body width 368 µm.

Material examined. KKO1.1-12 33 specimens, KKO2.1-12 13 specimens, KKO3.1-12 23 specimens, KKO4.1-12 33 specimens and KKO5.1-12 31 specimens.

Distribution in Turkey. Bursa and Sakarya (Seniczak et al., 2013; Bezci et al., 2017)

General distribution. Southern Palearctic (Subías, 2018).

Amerobelbidae Grandjean, 1961

***Amerobelba decedens* Berlese, 1908 (Figure 7b)**

Measurements. Body length 689 µm and body width 413 µm.

Material examined. KKO1.1-12 2 specimens.

Distribution in Turkey. Sakarya (Baran & Şimşek, 2012).

General distribution. Palearctic (Centromeridional Europe) (Subías, 2018).

Oppiidae Sellnick, 1937

***Berniniella (B.) bicarinata* (Paoli, 1908) (Figure 7c)**

Measurements. Body length, 224 µm and body width, 94 µm.

Material examined. KKO1.1-12 95 specimens, KKO2.1-12 49 specimens, KKO3.1-12 49 specimens, KKO4.1-12 93 specimens and KKO5.1-12 234 specimens.

Distribution in Turkey. Yozgat (Toluk & Ayyildiz, 2008b).

General distribution. Palearctic region (Subías, 2018).

Tectocephidae Grandjean, 1954

***Tectocephus alatus* Berlese, 1913 (Figure 7d)**

Measurements. Body length 346 µm and body width 192 µm.

Material examined. KKO1.1-12 41 specimens, KKO2.1-12 38 specimens, KKO3.1-12 20 specimens, KKO4.1-12 56 specimens and KKO5.1-12 30 specimens.

Distribution in Turkey. Bolu (Toluk et al., 2017).

General distribution. Palearctic region (Subías, 2018).

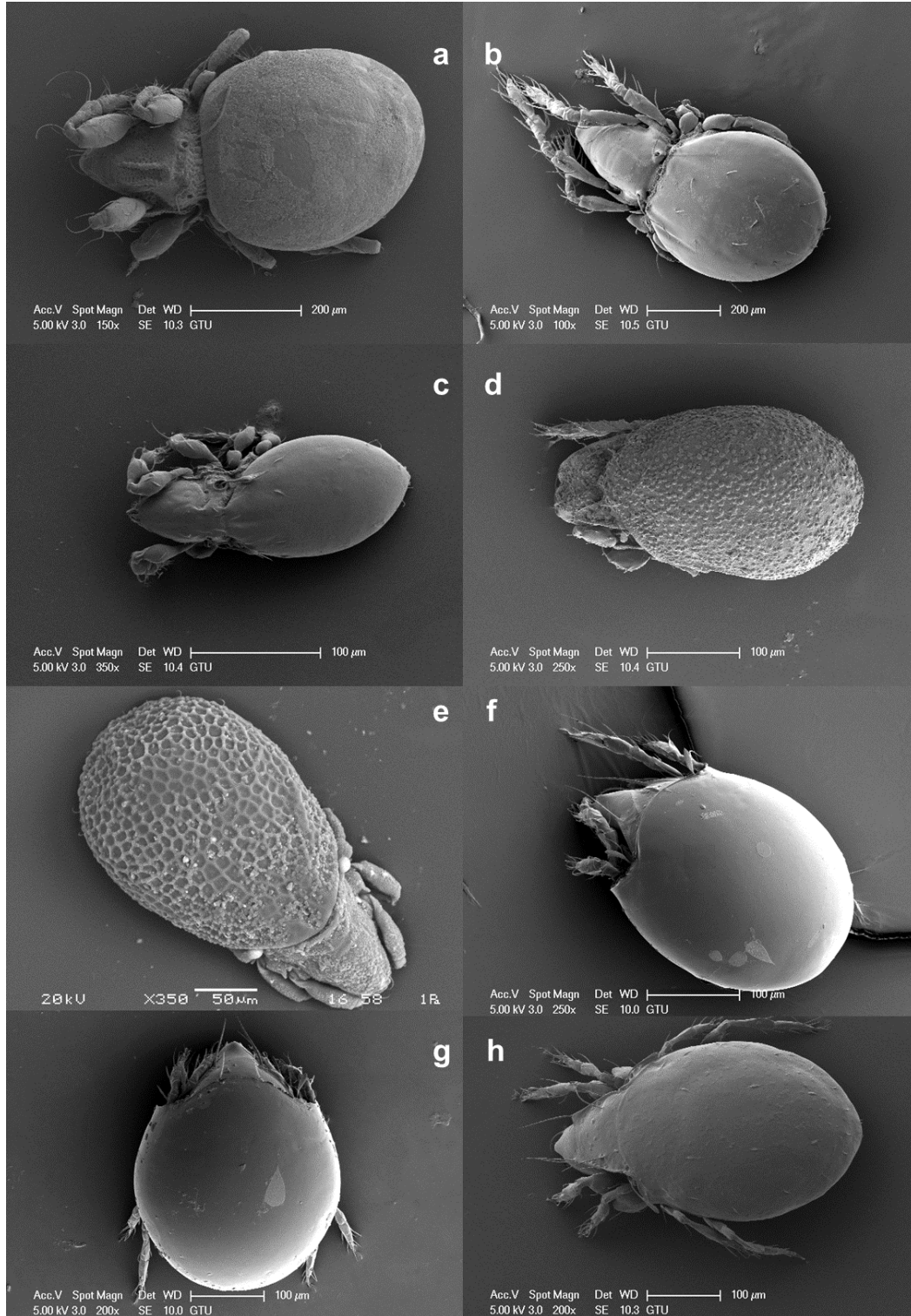


Figure 7. SEM images of a) *Eremaeus hepaticus cordiformis*, b) *Amerobelba decedens*, c) *Berniniella (B.) bicarinata*, d) *Tectocephus alatus*, e) *Micreremus brevipes*, f) *Chamobates (Xiphobates) interpositus*, g) *Chamobates (Xiphobates) sergienkoe* and h) *Oribatula (Zygoribatula) frisiae*.

Micreremidae Grandjean, 1954

***Micreremus brevipes* (Michael, 1888) (Figure 7e)**

Measurements. Body length, 308 µm and body width, 166 µm.

Material examined. KKO1.1-12 5 specimens, KKO2.1-12 1 specimen and KKO3.1-12 2 specimens.

Distribution in Turkey. Sakarya (Baran, 2016).

General distribution. Palearctic region (Subías, 2018).

Chamobatidae Thor, 1937

***Chamobates (Xiphobates) interpositus* Pschorn-Walcher, 1953 (Figure 7f)**

Measurements. Body length 311 µm and body width 222 µm.

Material examined. KKO1.1-12 124 specimens, KKO2.1-12 176 specimens, KKO3.1-12 111 specimens, KKO4.1-12 112 specimens and KKO5.1-12 83 specimens.

Distribution in Turkey. Ankara (Grobler et al., 2004).

General distribution. Mediterranean (Subías, 2018).

***Chamobates (Xiphobates) sergienkoe* Shaldybina, 1980 (Figure 7g)**

Measurements. Body length 337 µm and body width 279 µm.

Material examined. KKO1.1-12 40 specimens, KKO2.1-12 36 specimens, KKO3.1-12 35 specimens, KKO4.1-12 43 specimens and KKO5.1-12 25 specimens.

Distribution in Turkey. Giresun (Bayartogtokh et al., 2002).

General distribution. Southern Palearctic (Subías, 2018).

Oribatulidae Thor, 1929

***Oribatula (Zygoribatula) frisiae* (Oudemans, 1900) (Figure 7h)**

Measurements. Body length 428 µm and body width 247 µm.

Material examined. KKO1.1-12 179 specimens, KKO2.1-12 219 specimens, KKO3.1-12 116 specimens, KKO4.1-12 195 specimens and KKO5.1-12 115 specimens.

Distribution in Turkey. Ankara (Grobler et al., 2005).

General distribution. Holarctic region (frequently Palearctic) (Subías, 2018).

Scheloribatidae Grandjean, 1933

***Scheloribates (S.) laevigatus* (Koch, 1835) (Figure 8a)**

Measurements. Body length 419 µm and body width 257 µm.

Material examined. KKO1.1-12 65 specimens, KKO2.1-12 196 specimens, KKO3.1-12 48 specimens, KKO4.1-12 104 specimens and KKO5.1-12 46 specimens.

Distribution in Turkey. Konya (Dik et al., 1999).

General distribution. Semicosmopolitan (Subías, 2018).

Protoribatidae J. & P. Balogh, 1984***Protoribates (P.) capucinus* Berlese, 1908 (Figure 8b)**

Measurements. Body length 341 µm and body width 149 µm.

Material examined. KKO1.1-12 1 specimen, KKO2.1-12 2 specimens and KKO5.1-12 2 specimens.

Distribution in Turkey. Erzurum and Konya, (Ayyıldız, 1988b; Dik et al., 1999).

General distribution. Cosmopolitan (Subías, 2018).

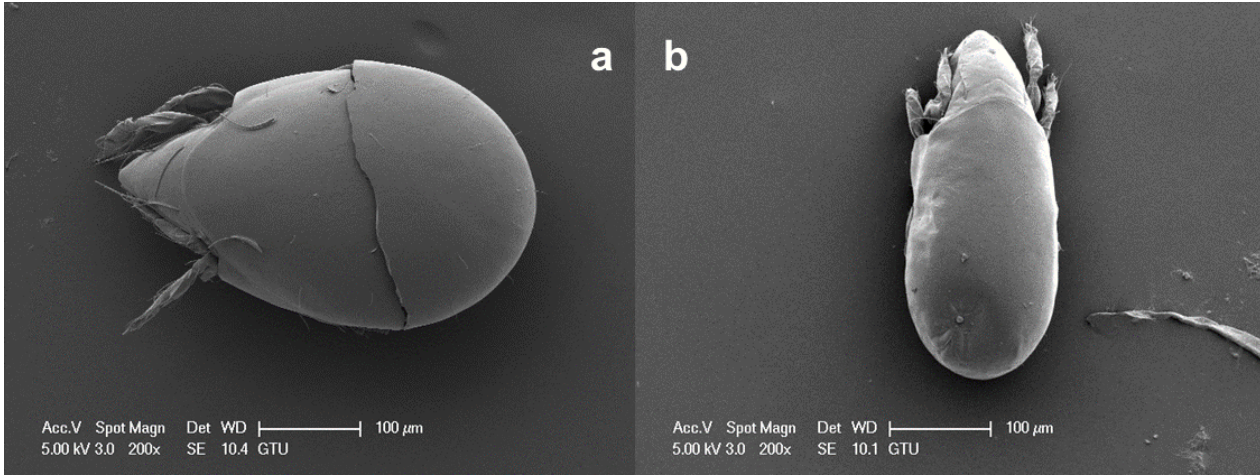


Figure 8. SEM images of a) *Schelorbates (S.) laevigatus* and b) *Protoribates (P.) capucinus*.

Conclusions

A total of 3,815 oribatid mites were allocated to 18 families and 22 species. One family (Parakalummidae), two genera (*Masthermannia* and *Cultroribula*) and four species [*M. mammillaris*, *C. bicultrata*, *N. (N.) bulanovae*, *A. integer*] are new records for Turkey. In the whole fauna, macropyline type oribatids represented 1.36% and brachypyline type oribatids 98.6% (29.2% picnonotic, 69.4% poronotic). Fifty percent of the Oribatid mites collected from Kocaeli City Forest have Palearctic distribution, 18.2% have Cosmopolitan, 13.6% have Mediterranean, 9.09% have Holarctic and 9.09% have semi cosmopolitan distribution.

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