Contribution to the knowledge of Entomobryomorpha (Hexapoda: Collembola) from Northeastern Iran with new records and a key to the species

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ABSTRACT. Soil-dwelling Entomobryomorphan Collembola from the Northeast of Iran were sampled for the first time as part of a biodiversity surveying study with the aim of improving ecosystem conservation. Materials were obtained by sampling in three different ecosystems including forest, rangeland and agricultural fields between 2018 and 2019. The specimens were cleared using either Nesbitt’s fluid or lactic acid and permanent microscopic slides were prepared using Hoyer’s medium. As the result of this study, twenty-nine species belonging to twenty-two genera and five families of the order Entomobryomorpha were identified. Among them, two genera and eight species are recorded for the first time from Iran. The new records are Desoria trispinata (MacGillivray, 1896), Drepanosira hussi Neuherz, 1976, Heteromurtrella sp., Orchesella flavescens (Bourlet, 1839), Willowsia bartkei Stach, 1965, Agrenia sp., and Isotomiella gracilimacronata Rusek, 1981. Micrographs of their important features and a key to the species are also provided.

Key words: checklist, agricultural species, forest species, soil fauna, springtails

INTRODUCTION

Collembola with approximately 9,000 published species worldwide are one of the most successful, abundant, and dominant micro-arthropods in most terrestrial ecosystems (Buda et al., 2020; Sharman et al., 2020; Kuyucu & Chown, 2021; Saifutdinov et al., 2021; Bellinger et al., 1996–2021). Order Entomobryomorpha with the largest species number are characterized by the reduction of first thoracic segment
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i.e. tergite of Th I is reduced and hidden under the tergite of Th II, well-developed furca, presence of sensilla on body and antennae, chaetae and sometimes scales covering the body segments (Jordana, 2012; Zhang et al., 2015, 2019). Based on Soto-Adames et al. (2008), the suprageneric classification of the order Entomobryomorpha includes four superfamilies: Tomoceroidea, Isotomoidea, Entomobryoidea, and Coenaletoidea. Furthermore, these superfamilies are further divided into eleven families: Oncopoduridae, Tomoceridae, Isotomidae, Actaletidae, Protentomobryidae, Orchesellidae, Paronellidae, Praentomobryidae, Entomobryidae, Oncobyridae, and Coenaletidae.

Iran with a surface area of 1648000 square kilometers has a variety of terrestrial ecosystems which have not yet been explored in terms of species diversity (Sadrizadeh, 2001). The most previous studies on Collembola have been done in the north and west of the country (e.g., Kahararian et al., 2012; Daghighi et al., 2013a, 2013b; Shoeibi et al., 2013; Kahararian, 2019; Yahyapour et al., 2019b; Shayanmehr et al., 2020a; Yoosefi Lafooraki et al., 2020a). Nevertheless, the fauna of Collemobla in Northern Khorasan province has never been studied. Literature review showed that the order of Entomobryomorpha consists of 105 species belonging to 34 genera of four families (Mehrafrooz Mayvan et al., 2015; Kahrarian, 2019; Shayanmehr & Yahyapour, 2019; Yahyapour et al., 2019a; Yoosefi Lafooraki et al., 2020b; Shayanmehr et al., 2020c). Therefore, the present study aims to a) collect, identify and add more data to the Collembola fauna of Iran, specifically focus on northeastern part of Iran and, b) to provide an identification key to the Collembola species reported from the north Khorasan province in Iran.

MATERIAL AND METHODS

Study area and sampling sites

The study area, North Khorasan province (Fig. 1) located in North-East, Iran and lies between 36°37’ to 38°17’ N latitude and 55°53’ to 58°20’ E longitude and has an area of about 28,400 km². The altitude is from 1,000 to 2,500 m above sea level (Meghdadi & Kamkar, 2011) and it has a common border in the north east with Turkmenistan. The province has a moderate climate, with an average annual rainfall about 250 mm (Moshaverinia et al., 2012). The minimum and maximum temperatures recorded in the North Khorasan province are -15 and +40 degrees, respectively.

Samples were taken from three different ecosystems including the forest of Darkesh-Jozak, the Golil-Sarany rangeland conservation area, and three alfalfa fields in the vicinity of Shirvan city (37°23’48″N latitude and 57°55’46″E longitude). The latter was a representative of an agricultural ecosystem. The Darkesh-Jozak forest is a part of Hycrnian forests has an area of about 22,500 hectares with a climate of a cold-humid type according to Amberger coefficient (Mashayekhan et al., 2015a). Its elevation ranges from 1000 m to more than 2455 m above sea level (Mashayekhan et al., 2015b). The sampling site is located between 37°23’ to 37°26’ N latitude and 56°43’ to 56°58’ E longitude. The average annual rainfall in this region is 377 mm and the average annual temperature is 10.6 °C. The highest rainfall is in April (61.53 mm) and the lowest in September (7.12 mm). The minimum and maximum annual temperature is -10.69 °C in January and + 33.4°C in July (Karimi et al., 2016). The rangeland area under study is the Golil-Sarany protected rangeland. This protected area with 17800 hectares is located in north of Shirvan city located between 37°42’ to 37°54’ N latitude and 57°13’ to 57°52’ E longitude. The lowest altitude in this area is about 1422m and the highest one is about 2922m above sea level (Farkhani, 2014). The third sampling site, as representatives of agricultural systems, were three alfalfa fields in the vicinity of Shirvan.

Collembola sampling

The soil samples were collected with a soil Corer of 5 in diameter and to a depth of 0–10 cm. Soil sampling commenced in June 2018 and continued monthly until June 2019. Sampling was carried out between the hours of 8.00 and 10.00 am on each date. Each sample was immediately placed individually
in a sealed plastic bag and transferred to the laboratory. Collembola were extracted from each soil sample by using a modified Berlese-Tullgren funnel and transferred into 75% ethanol. Extracted specimens were stored for later identification. The specimens were cleared using either Nesbitt’s fluid or lactic acid and mounted on microscopic slides. Permanent microscopic slides were prepared using Hoyer’s medium and examined at high magnification with help of a compound light microscope under phase contrast illumination. Specimens were identified using Potapov (2001), Fjellberg (2007), Jordana (2012) and other relevant literature. Voucher specimens are deposited at Systematic Entomology Laboratory, Ferdowsi University of Mashhad, Iran. For each species, their bibliographical data, habitat, ecology and distribution are provided here. New records are denoted by an asterisk (*).

The following abbreviations are used in the text: Abd = abdominal segment; Ant = antennal segment; Man = manubrium; Mac = macrochaetae; PAO = post antennal organ; Th = thoracic segment; Tib = tibiotarsi; Tricho = trichobothria.

RESULTS

Among twenty-nine identified Collembola species from the North Khorasan province, two genera and eight species are recorded for the first time for fauna of Iran. These new records are as follows: Desoria trispinata (MacGillivray 1896), Drepanosira hussi Neuherz 197, Heteromurtrella sp., Orchesella flavescens (Bourlet 1839), Willowsia bartkei Stach 1965, Agrenia sp., and Isotomiella gracilimucronata Rusek 1981. Below, the taxonomic information of all identified species with some ecological information and micrographs of their important features are presented.
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**Taxonomy**

Class Collembola Lubbock, 1871
Order Entomobryomorpha Börner, 1913
Superfamily Entomobryoidea Womersley, 1934
Family Entomobryidae Schäffer, 1896
Subfamily Entomobryinae Schäffer, 1896
Genus *Drepanura* Schött, 1891

*Drepanura* sp.

**Material examined:** 3 specimens, Darkesh-Jozak forest, 37°25′32″N, 56°45′25″E, 1284 m a.s.l, collected from soil under Oak trees (*Quercus castaneifolia*), July 2018; 2 specimens, Golil-Sarany rangeland, 37°48′12″N, 57°56′24″E, 1645 m a.s.l, collected from soil under Juniper trees (*Juniperus excelsa*), July 2018.

**Habitat and distribution in Iran:** We are unable to identify this taxon to species level. This species has already been collected from straw in Kermanshah (Qasr-e-shirin) by Kahrarian et al. (2014).

Genus *Entomobrya* Rondani, 1861

*Entomobrya corticalis* (Nicolet, 1841)

**Material examined:** 3 specimens, Darkesh-Jozak forest, 37°25′17″N, 56°40′29″E, 1255 m a.s.l, collected from soil under Oak trees (*Quercus castaneifolia*), April 2018; 3 specimens, Golil-Sarany rangeland, 37°49′11″N, 57°55′33″E, 1629 m a.s.l, collected from soil under Juniper trees (*Juniperus excelsa*), April 2018; 2 specimens, Zoeram village, 37°19′42″N, 57°44′31″E, 1258 m a.s.l, collected from soil in alfalfa fields, April 2018.

**Habitat and distribution in Iran:** This species has already been reported from soil and leaf litter in Golestan (Golestan National Park) by Cox (1982) and Khanahmadi (2018).

**General distribution and ecology:** This species has a Palaearctic distribution and it is common under bark on dead trees, both hardwood and conifers (Fjellberg, 2007).

Genus *Sinella* Brook, 1882

*Sinella* sp.

**Material examined:** 1 specimen, Darkesh-Jozak forest, 37°25′17″N, 56°40′29″E, 1255 m a.s.l, collected from soil under Oak trees (*Quercus castaneifolia*), July 2018; 1 specimen, Golil-Sarany rangeland, 37°49′11″N, 57°55′33″E, 1629 m a.s.l, collected from soil under Juniper trees (*Juniperus excelsa*), September 2018.

Subfamily Lepidocyrtinae Wahlgren, 1906

Genus *Lepidocyrtus* Bourlet, 1839

*Lepidocyrtus lanuginosus* (Linnaeus in Gmelin, 1790)

**Material examined:** 4 specimens, Darkesh-Jozak forest, 37°27′06″N, 56°49′27″E, 1593 m a.s.l, collected from soil under Oak trees (*Quercus castaneifolia*), November 2018; 3 specimens, Golil-Sarany rangeland, 37°49′50″N, 57°54′02″E, 1759 m a.s.l, collected from soil under yarrow plants (*Achillea pachycephala*), November 2018; 2 specimens, Mayvan village, 37°12′41″N, 58°02′14″E, 1357 m a.s.l, collected from soil of alfalfa field, November 2018.

**Habitat and distribution in Iran:** This species was already reported from soil and leaf litter in Mazandaran, Guilan, East Azarbaijan and Golestan (Gorgan, Palangpa forest) by Cox (1982) and Hosseini et al. (2016).

**General distribution and ecology:** Holarctic (Babenko et al., 2019).
Genus *Pseudosinella* Schäffer, 1897

*Pseudosinella octopunctata* Börner, 1901

**Material examined:** 5 specimens, Darkesh-Jozak forest, 37°27’01”N, 56°48’46”E, 1573 m a.s.l, collected from soil under maple trees (*Acer monspessulanum* sub sp. *turcomanicum*), May 2019; 2 specimens, Golil-Sarany rangeland, 37°50’38”N, 57°51’46”E, 1972 m a.s.l, collected from soil under centaury plants (*Centaurea aucheri*), May 2019; 4 specimens, Oghaz village, 37°32’19”N, 58°10’43”E, 1604 m a.s.l, collected from soil of alfalfa field, May 2019.

**Habitat and distribution in Iran:** It has already been reported from soil, leaf litter, moss on rocks and in a rice field in Zanjan, Guilan, East Azarbaijan, West Azarbaijan, Mazandaran (Sari, Babolsar, Qaemshahr, Larijan, Babol), Tehran, Isfahan (Zarrinshahr), Golestan (Kordkuy, Imam Reza forest, Palangpa forest, Gorgan, Alangdarreh forest, Naharkhoran forest, Ziarat), Kermanshah (Sar-e-pol-e-Zahab, Patagh, Qarah Bolagh, Rijab, Habibvand, Sahneh, Sonqor, Guilan-e-Gharb, Qasr-e-shirin, Kangavar, Paveh, Harsin, Gahvareh, Esalamabad-e-gharb, Tazeh abad, Javanrud, Sonqor), Kerman (Shahdad, Sirch village) and Lorestan by Cox (1982), Yahyapour (2012), Yoosfeli Lafooraki (2014), Yoosfeli Lafooraki & Shayanmehr (2013, 2014), Qazi & Shayanmehr (2014), Kahrarian et al. (2014, 2015), Balvasi et al. (2015), Mehrafroz Mayvan et al. (2015), Darvish-Motevalli (2016), Hosseini et al. (2016), Alijani-Ardeshir et al. (2017), Ghasemi Cherati (2017), Moradi et al. (2018) and Abdolalizadeh et al. (2019).

**General distribution and ecology:** Cosmopolitan. A characteristic species in dry, warm habitats with patchy vegetation such as scree and gravel/sand slopes (Fjellberg, 2007).

**Subfamily Seirinae Yosii, 1961**

Genus *Seira* Lubbock, 1869

*Seira atlantica* Negri, Pellechia & Fanciulli, 2005

**Material examined:** 7 specimens, Varaghi village, 37°22’16”N, 57°45’16”E, 1146 m a.s.l, collected from soil of alfalfa field, August 2018.

**Habitat and distribution in Iran:** This species already has been reported from soil and leaf litter under of alfalfa fields in Zanjan (Kheyrabad) by Shayanmehr et al. (2020b).

**General distribution and ecology:** Morocco (Negri et al., 2005) and Iran (Shayanmehr et al. 2020b).

**Subfamily Willowsiinae Yoshii & Suhardjono, 1989**

Genus *Drepanosira* Bonet, 1942

*Drepanosira hussi* Neuherz, 1976 *

**Material examined:** 5 specimens, Darkesh-Jozak forest, 37°25’32”N, 56°45’25”E, 1284 m a.s.l, collected from soil under Oak trees (*Quercus castaneifolia*), May 2019.

**Habitat and distribution in Iran:** This species is reported here for the first time (Fig. 2A–B).

**General distribution and ecology:** Paleotropical (Baquero et al., 2015).

Genus *Willowsia* Shoenbotham, 1917

*Willowsia bartkei* Stach, 1965 *

**Material examined:** 3 specimens, Darkesh-Jozak forest, 37°27’09”N, 56°49’49”E, 1543 m a.s.l, collected from soil under Oak trees (*Quercus castaneifolia*), October 2018.

**Habitat and distribution in Iran:** The occurrence of this species (Fig. 2C–E) is reported here for the first time in Iran.

**General distribution and ecology:** Vietnam and Iran (Zhang, 2015).
Family Orchesellidae Börner, 1906
Subfamily Heteromurinae Absolon & Kseneman, 1942
Genus Heteromurtrella Mari Mutt, 1979
Heteromurtrella sp.

Material examined: 3 specimens, Golil-Sarany rangeland, 37°50′38″N, 57°51′51″E, 1972 m a.s.l, collected from soil under Juniper trees (Juniperus excelsa), January 2019.

Habitat and distribution in Iran: We were unable to identify this taxon to species level. The occurrence of this genus (Fig. 2F–G) in Iran is reported for the first time.

Genus Heteromurus Wankel, 1860
Heteromurus nitidus (Templeton, 1835)

Material examined: 10 specimens, Darkesh-Jozak forest, 37°25′32″N, 56°45′25″E, 1284 m a.s.l, collected from soil under Oak trees (Quercus castaneifolia), July 2018; 3 specimens, Golil-Sarany rangeland, 37°48′12″N, 57°56′24″E, 1645 m a.s.l, collected from soil under Juniper trees (Juniperus excelsa), July 2018; 7 specimens, Mayvan village, 37°12′41″N, 58°02′14″E, 1357 m a.s.l, collected from soil of alfalfa field, July 2018.

Habitat and distribution in Iran: This species (Fig. 3) had already been reported from soil and leaf litter in Guilan, Mazandaran (Savadkhooh, Sari, Babol, Qaemshahr), Kermanshah (Harsin) and Golestan (kordkouy, Palangpa forest) by Cox (1982), Yoosefi Lafooraki (2014), Yoosefi Lafooraki & Shayanmehr (2014), Kahrarian et al. (2014), Mehrafrooz Mayvan et al. (2015), Hosseini et al. (2016), Darvish-Motevalli (2016), Alijani-Ardeshir et al. (2017) and Ghasemi Cherati (2017).

General distribution and ecology: This species has a cosmopolitan distribution and it is common in deep forest soil, under the rocks and rotting timber. Less common in meadows (Fjellberg, 2007).

Heteromurus variabilis (Martynova, 1974)

Material examined: 4 specimens, Darkesh-Jozak forest, 37°26′15″N, 56°47′51″E, 1284 m a.s.l, collected from soil under Boissier pear trees (Pyrus boissieriana), April 2019.

Habitat and distribution in Iran: This species has already been reported from soil and leaf litter in Mazandaran (Sari) by Ghasemi Cherati (2017).

General distribution and ecology: Palaearctic (Mari Mutt, 1980).

Subfamily Orchesellinae Börner, 1906
Genus Orchesella Templeton, 1835
Orchesella cincta (Linnaeus, 1758)

Material examined: 10 specimens, Darkesh-Jozak forest, 37°25′14″N, 56°40′30″E, 1325 m a.s.l, collected from soil under maple trees (Acer monspessulanum sub sp. turcomanicum), June 2018; 5 specimens, Golil-Sarany rangeland, 37°48′17″N, 57°56′22″E, 1591 m a.s.l, collected from soil under barberry plants (Berberis integerrima), June 2018.

Habitat and distribution in Iran: This species has already been reported from leaf litter and moss on the rocks in Mazandaran (Babol, Neka, Savadkhooh, Forest of Jawarom, Alasht, Serin village, Larijan) and Golestan (Kordkuy, Imam Reza forest, Palangpa forest) by Yoosefi Lafooraki (2014), Yoosefi Lafooraki & Shayanmehr (2013, 2014), Balvasi et al. (2015), Hosseini et al. (2016) and Yahyapour et al. (2019).

General distribution and ecology: This species has a Holarctic distribution and usually found in litter around foot of trees, in moss on tree trunks and rocks, sometimes in meadows (Fjellberg, 2007).
Figure 2. *Drepanosira hussi* Neuherz, 1976: A. Body scales (40X); B. Muro falcate with basal spine (40X); *Willowsia bartkei* Stach, 1965: C. Muro (40X); D. Body scales (40X); E. Dark blue pigment on Abd II & III.; *Heteromurtrella* sp.: F. Omma without PAO (40X), G. 1+1 central mac. on Abd II (40X).
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**Orchesella flavescens** (Bourlet, 1839)*

**Material examined:** 8 specimens, Golil-Sarany rangeland, 37°52′34″N, 57°53′15″E, 1952 m a.s.l, collected from soil under *Alyssum inflatum*, December 2018.

**Habitat and distribution in Iran:** This species (Fig. 4A) is reported here for the first time in Iran.

**General distribution and ecology:** This species has a Holarctic distribution and often found in moss and litter in damp habitats (Fjellberg, 2007).

**Superfamily Isotomoidea Schäffer, 1896**

**Family Isotomidae Börner, 1913**

**Subfamily Anurophorinae Börner, 1901**

**Genus Hemisotoma** Bagnall, 1949

**Hemisotoma pontica** (Stach, 1947)

**Material examined:** 3 specimens, Darkesh-Jozak forest, 37°27′01″N, 56°48′46″E, 1573 a.s.l, collected from soil under maple trees (*Acer monspessulanum* sub sp. *turcomanicum*), March 2019.

**Habitat and distribution in Iran:** This species has already been reported from soil in Lorestan, Kermanshah and Tehran by Moravvej (2003), Kahrarian & Arbea (2013) and Moradi et al. (2018).

**General distribution and ecology:** Palaearctic (Potapov, 2001; Kahrarian & Arbea, 2013).

**Genus Isotomiella** Bagnall, 1939

**Isotomiella gracilimucronata** Rusek, 1981*

**Material examined:** 4 specimens, Golil-Sarany rangeland, 37°49′50″N, 57°54′02″E, 1759 m a.s.l, collected from soil under yarrow plants (*Achillea pachycephala*), November 2018.

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**Figure 3.** *Heteromurus nitidus* (Templeton, 1835): A–B. Macrochaetotaxy in head (A) and in Th II (B) (40X); C. Subsegmentation (arrow) of Ant I (40X).
Figure 4. *Orchesella flavescens* (Bourlet, 1839): A. Ant I subdivided in short basal (indicated by arrow) and long apical part (40X); *Isotomiella gracilimucronata* Rusek, 1981: B. Mucro with three toothed indicated by arrow (100X); C. Manubrium with 4+4 anterior chaetae (2+2, 1+1, 1+1) (100X).
Habitat and distribution in Iran: The occurrence of this species (Fig. 4B–C) in Iran is reported here for the first time.


*Isotomiella minor* (Schäffer, 1896)

**Material examined:** 5 specimens, Darkesh-Jozak forest, 37°26′43″N, 56°47′21″E, 1540 m a.s.l, collected from soil under Oak trees (*Quercus castaneifolia*), February 2019; 6 specimens, Golil-Sarany rangeland, 37°50′38″N, 57°51′51″E, 1972 m a.s.l, collected from soil under Juniper trees (*Juniperus excelsa*), February 2019.

**Habitat and distribution in Iran:** This species has already been reported from soil (*Quercus* sp., *Prunus* sp., *Pinus* sp.), and leaf litter in Mazandaran (Sari, Nowshahr; Noor, Forest of Sisangan), Guilan (Rasht), East Azarbaijan, Tehran, Kermanshah (Shabankareh village, Patagh), Golestan (Kordkuy, Palangpa forest), Kerman (Koohpayeh village) and Lorestan by Cox (1982), Moravvej et al. (2007), Yahyapour (2012), Daghighi (2012), Gahramaninézhad et al. (2013), Daghighi et al. (2013a, 2013b), Yousefi Lafaoraki (2014), Yousefi Lafaoraki & Shayanmehr (2014), Amiri & Kahrarian (2015), Arbea & Kahrarian (2015), Mehrafroz Mayvan et al. (2015), Hosseini et al. (2016), Ghasemi Cherati (2017), Abdolalizadeh et al. (2019), Moradi et al. (2018) and Kahrarian (2019).

**General distribution and ecology:** Holarctic. Common species in different habitat, apparently with a preference for humid forest soils rather than high mountains (Fjellberg, 2007).

**Genus Folsomia Willem, 1902**

*Folsomia penicula* Bagnall, 1939

**Material examined:** 5 specimens, Darkesh-Jozak forest, 37°25′17″N, 56°40′29″E, 1255 m a.s.l, collected from soil under Oak trees (*Quercus castaneifolia*), September 2018.

**Habitat and distribution in Iran:** This species has already been reported from soil and leaf litter under oak trees (*Quercus* sp.) in East Azarbaijan, Golestan (Gorgan), Guilan (Rasht), Mazandaran (Nowshahr, Kojur, Lashkenar, Bahnmir), Kermanshah (Shikh salaeh village, Ghap Gholi village) and Tehran by Cox (1982), Falahati et al. (2011), Daghighi (2012), Daghighi et al. (2013a, 2013b), Qazi & Shayanmehr (2014), Yousefi Lafaoraki (2014), Yousefi Lafaoraki & Shayanmehr (2014), Arbea & Kahrarian (2015), Ghasemi Cherati (2017) and Mehrafroz Mayvan et al. (2015).

**General distribution and ecology:** This species has a Palaearctic distribution and it is abundant in composted leaf litter (Fjellberg, 2007).

*Folsomia quadrioculata* (Tullberg, 1871)

**Material examined:** 5 specimens, Darkesh-Jozak forest, 37°26′43″N, 56°47′21″E, 1540 m a.s.l, collected from soil under maple trees (*Acer monspessulanum* sub sp. *turcomanicum*), Agust 2018; 6 specimens, Golil-Sarany rangeland, 37°50′38″N, 57°51′51″E, 1972 m a.s.l, collected from soil under centaury plants (*Centaurea aucheri*), August 2019.

**Habitat and distribution in Iran:** This species has already been reported from soil and leaf litter in Mazandaran, Guilan, East Azarbaijan, West Azarbaijan, Kermanshah (Char zabar, Shikh salaeh village, Ghap Gholi village, Sia Khor village) and Lorestan by Cox (1982), Amiri & Kahrarian (2015), Arbea & Kahrarian (2015), and Moradi et al. (2018).

**General distribution and ecology:** Holarctic. This species has no any clear habitat preferences and occurs in a variety of habitats (Fjellberg, 2007).
Subfamily Isotominae Schäffer, 1896

Genus Agrenia Börner, 1906

Agrenia sp.*

Material examined: 4 specimens, Zoeram village, 37°19′11″N, 57°44′16″E, 1283 m a.s.l, collected from soil under alfalfa fields, October 2018.

Habitat and distribution in Iran: We were unable to identify this taxon to species level. The occurrence of the genus in the study area is reported here for the first time in Iran.

Genus Desoria Nicolet in Desor, 1841

Desoria trispinata (MacGillivray, 1896)*

Material examined: 8 specimens, Darkesh-Jozak forest, 37°25′32″N, 56°45′25″E, 1284 m a.s.l, collected from soil under Oak trees (Quercus castaneifolia), May 2019.

Habitat and distribution in Iran: The occurrence of this species (Fig. 5A–C) is reported for the first time in Iran.

General distribution and ecology: Cosmopolitan. This species can be found in compost and other organic debris (Fjellberg, 2007; Babenko et al., 2019).

Genus Isotoma Bourlet, 1839

Isotoma viridis Bourlet, 1839

Material examined: 8 specimens, Darkesh-Jozak forest, 37°27′01″N, 56°48′46″E, 1573 m a.s.l, collected from soil under Oak trees (Quercus castaneifolia), January 2019.

Habitat and distribution in Iran: This species has already been reported from soil and leaf litter in East Azerbaijan, West Azerbaijan, Mazandaran (Sari, Babol), Kermanshah (Shabankareh, Paveh) and Golestan (Golestan National Park) by Cox (1982), Yahyapour (2012), Amiri & Kahrarian (2015), Alijani-Ardeshir et al. (2017), Khanahmadi (2018) and Kahrarian (2019).

General distribution and ecology: Holarctic. Common and widely distributed in a variety of habitats, both in forest, meadows, seashores and alpine tundra. It is possibly this species tolerates some drier conditions (Fjellberg, 2007).

Genus Isotomurus Börner, 1903

Isotomurus graminis Fjellbeg, 2007

Material examined: 8 specimens, Golil-Sarany rangeland, 37°52′34″N, 57°53′15″E, 1952 m a.s.l, collected from soil under Alyssum inflatum, December 2018.

Habitat and distribution in Iran: This species has already been reported from soil in alfalfa fields in North khorasan by Mehrafroz Mayvan & Greenslade (2020).

General distribution and ecology: Palaearctic. Usually individuals are found in large numbers in humid disturbed open grasslands, rarer in forests or besides standing ponds and lakes or streams (Fjellberg, 2007).

Genus Parisotoma Bagnall, 1940

Parisotoma notabilis (Schäffer, 1896)

Material examined: 10 specimens, Darkesh-Jozak forest, 37°25′14″N, 56°40′30″E, 1325 m a.s.l, collected from soil under maple trees (Acer monspessulanum sub sp. turcomanicum), June 2018; 5 specimens, Golil-Sarany rangeland, 37°48′17″N, 57°56′22″E, 1591 m a.s.l, collected from soil under barberry plants (Berberis integerrima), June 2018; 9 specimens, Gelyan village, 37°18′07″N, 57°55′33″E, 1188 m a.s.l, collected from soil of alfalfa field, June 2018.
New reports of Iranian springtails

**Figure 5.** *Desoria trispinata* (MacGillivray, 1896): A. Apical ring of Tib III (40X); B. Macrochaetae on Abd V smooth (40X); C. Mucro; *Tomocerus vulgaris* (Tullberg, 1871): D. Mucro (40X); E. Dorsal spines on dens simple (40X).

**Habitat and distribution in Iran:** This species has already been reported from soil and leaf litter in different habitats in East Azarbaijan, West Azarbaijan, Zanjan, Tehran, Guilan (Rasht), Mazandaran (Noor, Royan, Kodirsar), Kermanshah (Shabankareh village, Patagh), Golestan (Kordkuy, Palangpa forest, Golestan National Park), Khuzestan, Kerman (Shahdad, Sirch village, Mahan, Sekonj village, Koohpayeh village) and Lorestan by Cox (1982), Moravvej et al. (2007), Kahrarian et al. (2012), Daghighi (2012), Daghighi et al. (2013a, 2013b), Yoosefi Lafooraki & Shayanmehr (2014), Amiri & Kahrarian (2015), Arbea & Kahrarian (2015), Hosseini et al. (2016), Ramezani & Mossadegh (2017), Khanahmadi (2018), Moradi et al. (2018), Abdolalizadeh et al. (2019) and Kahrarian (2019).

**General distribution and ecology:** Cosmopolitan. This species is a common and widely distributed species (Fjellberg, 2007; Babenko et al., 2019).
Subfamily Proisotominae Stach, 1947
Genus Folsomides Stach, 1922

*Folsomides parvulus* Stach, 1922

**Material examined:** 2 specimens, Golil-Sarany rangeland, 37°50′38″N, 57°51′51″E, 1972 m a.s.l, collected from soil under centaury plants (*Centaurea aucheri*), March 2019.

**Habitat and distribution in Iran:** It has already been reported from soil under *Morus* sp. trees, leaf litter and soil of a black cherry garden in East Azarbaijan, West Azarbaijan, Kermanshah (Harsin, Chahar Zebar-e-Oliya), Gilan (Rasht), Tehran, Semnan (Mahdishahr), Mazandaran (Savadkooh, Forest of Jawarom, Alasht, Serin village, Babolsar, Qaemshahr, Babol, Sari), Golestan (Kordkuy, Palangpa forest), Kerman (Mahan, Sekonj village) and Lorestan by Cox (1982), Yahyapour (2012), Kahrarian et al. (2012), Daghighi (2012), Daghighi et al. (2013a, 2013b), Qazi & Shayanmehr (2014), Yoosefi Lafooraki & Shayanmehr (2013, 2014), Amiri & Kahrarian (2015), Hosseini et al. (2016), Alijani-Ardeshir et al. (2017), Moradi et al. (2018) and Abdolalizadeh et al. (2019).

**General distribution and ecology:** Cosmopolitan. Usually found on warm sunny slopes with sand/gravel and thermophilic vegetation (Fjellberg, 2007).

Family Paronellidae Börner, 1906
Subfamily Cyphoderinae Börner, 1906
Genus Cyphoderus Nicolet, 1842

*Cyphoderus albinus* Nicolet, 1842

**Material examined:** 2 specimens, Darkesh-Jozak forest, 37°25′32″N, 56°45′25″E, 1284 m a.s.l, collected from soil under Oak trees (*Quercus castaneifolia*), July 2018.

**Habitat and distribution in Iran:** This species has already been reported from soil under plane trees (*Platanus* sp.), leaf litter in citrus garden and rice field in Gilan (Rasht), Tehran, Isfahan (Zarrinshahr), Mazandaran (Babolsar, Qaemshahr) and Kermanshah (Qasr-e-shirin, Parviz Khan and Kerman and Shahdad) by Daghighi (2012), Qazi & Shayanmehr (2014), Yoosefi Lafooraki (2014), Yoosefi Lafooraki & Shayanmehr (2014), Darvish-Motevalli (2016), Abdolalizadeh (2018) and Kahrarian (2019).

**General distribution and ecology:** Palaearctic. Probably widespread with ants (Fjellberg, 2007).

Superfamily Tomoceroidea
Family Tomoceridae Schäffer, 1896
Genus Tomocerus Nicolet, 1842

*Tomocerus vulgaris* (Tullberg, 1871)

**Material examined:** 5 specimens, Darkesh-Jozak forest, 37°26′43″N, 56°47′21″E, 1540 m a.s.l, collected from soil under Oak trees (*Quercus castaneifolia*), February 2019.

**Habitat and distribution in Iran:** This species (Fig. 5D-E) already has been reported from soil in Mazandaran, Gilan, East Azarbaijan, Zanjan, Kermanshah and Golestan by Cox (1982), Shayanmehr et al. (2013), Yoosefi Lafooraki (2014), Yoosefi Lafooraki and Shayanmehr (2014), Balvasi et al. (2015), Mehrafroz Mayvan et al. (2015), Kahrarian et al. (2014, 2015), Hosseini et al. (2016), Alijani-Ardeshir et al. (2017), Ghasemi Cherati (2017) and Khanahmadi (2018).

**General distribution and ecology:** Cosmopolitan. Common and widely distributed in forest litter, often in damp habitats (Fjellberg, 2007).
Key to the Entomobryomorpha species in Northeast of Iran
(Adapted from Potapov, 2001; Fjellberg, 2007; Soto-Adames et al., 2008; Jordana, 2012).

1. Body without scale or with a cover of sparse ciliated Mac (absent in two species), Abd IV–VI distinct, but if fused then shorter than length of Th II to Abd III (Isotomidae). ........................................ 4
   – Body with scale or with a cover of dense ciliated Mac (Fig. 6B–F), PAO absent. If present (one species), then strongly lobed. ................................................................. 2

2. Mucro short, hook-like (Entomobryidae). ......................................................... 14
   – Mucro long, elongate. ........................................................................................................ 3

3. Large species (up to 4-5 mm) with pigment and dark eye-spots. Ant strongly prolonged. Mucro with chaetae (Tomoceridae), Tib with several differentiated Mac on inner surface, Mid-section of mucro with more than 3 teeth, Dorsal spines of dens simple. .............................. ...Tomocerus vulgaris (Tullberg, 1871)
   – Small (<1.5 mm) white species without eyes. Ant normal. PAO absent. Mucro only with apical and subapical teeth. Dens dorsally with flattened, blade-like chaetae. ........................................... Cyphoderus Nicolet

4. PAO absent. Only white species without eyes, Mucro 3 toothed (Isotomiella Bagnall). .............................. 5
   – PAO present. Pigmented and some white species, Mucro 2 or 3 toothed. ........................................ 6

5. Man with 4+4 anterior chaetae (2+2, 1+1, 1+1), and 2+2 lateral chaetae. .............. I. gracilimucronata Rusek, 1981
   – Man with 5(6) + 5(6) anterior chaetae (2+2, 2+2 – 3+3, 1+1), and 3+3 lateral chaetae. I. minor (Schäffer, 1896)

6. All segments of Abd IV–VI fused (Folsomia Willem). ............................................................... 7
   – Abd IV demarcated from Abd V. ................................................................. 8

7. Man with 1+1 ventroapical chaetae, Ocelli 2+2, Th 2 with hind corner sensillum set within the p-row........ F. quadrioculata (Tullberg, 1871)
   – Man with more than 1+1 ventroapical chaetae, Ocelli 2+2, microsens on Th III and Abd III present .......... F. penicula Bagnall, 1939

8. Man with six or fewer mid-ventral anterior chaetae. ................................................................. 9
   – Man with at least eight chaetae in the mid-ventral anterior group. .............................................. 10

9. Man with two or more anterior chaetae, Abd V–VI fused, 5+5 ocelli........ Hemisotoma pontica (Stach 1947)
   – Man without anterior chaetae, Abd V–VI clearly demarcated, 2+2 ocelli....... Folsomides parvulus Stach, 1922

10. Tricho present on Abd IV, usually also on Abd II–III. Ventral tube with 3+3 laterodistal chaetae (rarely with more). ..............................Isotomurus graminis Fjellbeg, 2007
    – Tricho absent. If ventral tube has 3+3 lateral chaetae, then labial palp with 3 or 4 proximal chaetae. ...... 11

11. Subapical chaetae of dens long which extends beyond tip of mucro. Maxillary outer lobe without sublobal hairs. ................................................................. Agrenia Börner, 1906
    – Apical chaetae of dens shorter, not extending beyond tip of mucro. Maxillary outer lobe with 4 sublobal hairs. ................................................................................. 12

12. Ocelli at most 4-5 on each side. Eye-spots small, square or punctual with 3–4 ocelli on each side, Mucro with 3 teeth........................................ Parisotoma notabilis (Schäffer, 1896)
    – Ocelli 5–8 on each side. Eye-spot large, elongate, Mucro with 3 or 4 teeth. ........................................ 13

    – Tib with 8 apical chaetae. Man ventroapical chaetae spine-like, Ventoapical manubrial teeth simple, Mucro usually with a minute fourth tooth on the ventral edge, Abd V macrochaetae more than twice as long as tergite, Body uniformly coloured, without 3 longitudinal lines. ......... Isotoma viridis Bourlet, 1839

14. Abd IV in dorsal midline about 1.5 as long as Abd III (Fig. 6A). Ant I with a basal short subsegment (Orchesellidae). ................................................................. 15
    – Abd IV in dorsal midline more than twice as long as Abd III (Fig. 6B). Ant I not subdivided (Entomobryidae). ................................................................. 19
Figure 6. Morphological structures of Entomobryidae. A–B. different proportions of Abd III–IV in *Orchesella* (A) and *Seira* (B); C–F. scales from dorsal side of abdomen in *Seira* (C), *Heteromurus* (D), *Willowsia* (E) and *Tomocerus* (F).

15. Body with scales (Fig. 6D). Body pigment absent or pale (Heteromurinae). .................................................. 16
   — Body with normal chaetae only, no scales. Body with characteristic colour patterns (*Orchesella* Templeton). .................................................................................................................................................. 18

16. Abd II with 1+1 central mac, dental spines usually absent. ......................... *Heteromurtrella* Mari Mutt
   — Abd II with 2+2 central mac, Mucro with basal spine (*Heteromurus* Wankel, 1860) ......................... 17

17. 1+1 ocelli, Man with about 10+10 smooth dorsal chaetae, scales present on Ant III and legs. ................................. *H. nitidus* (Templeton, 1835)
   — 8+8 ocelli, Man without smooth dorsal chaetae, second row of base of labium without smooth chaetae. .... ................................................................. *H. variabilis* (Martynova, 1974)

18. Dorsal disc of Abd III entirely dark, only Abd III dark pigmented, Abd II pale. ..... *O. cincta* (Linnaeus, 1758)
   — Abd III at most with dorsolateral dark spots as part of longitudinal bands of the body or dark pattern broken into spots, Body with dorsolateral continuous longitudinal bands running from Th II to Abd II or further. Abd II never with a dark transverse band. Ant dark from base to tip of Ant II. ................................. *O. flavescens* (Bourlet, 1839)
19. Trich 2, 3, 3 on Abd II–IV; tergal sens formula as 11|022–3; mucro falcate without basal spine or lamella; scales present (Seirinae), Th III with 15 central Mac. ..........Seira atlantica Negri, Pellecchia & Fanciulli, 2005
   – Tricho 2, 3, 2 on Abd II–IV; tergal sens formula not 11|022–3; mucro falcate or bidentate; scales present or absent. ..................................................20

20. Body with normal chaetae only, no scales. ...............................................................................................................21
   – Body with chaetae and transparent scales (which easily fall off). ........................................................................23

21. Ocelli absent or 2+2, body without distinct colour patterns. Dens abruptly constricted just before tip. ..........22
   – Ocelli 8+8, most species with distinct colour patterns. Dens more gradually tapering towards tip. ............22

22. Mucro with two teeth, Chaetae on body not flattened, Abd III either completely dark......................................Entomobrya corticalis (Nicolet, 1841)
   – Mucro falcate, large Mac present on anterior margin of Th II, Mucro with basal spine. ... Drepanura Schott

23. Body scales pointed (Fig. 6E), with sharp striae, absent ventrally on dens (Willowsiinae)............................24
   – Body scales rounded, without sharp striae, also present ventrally on dens. ..................................................25

24. Mucro falcate, Mucronal basal spine present. ..........................................................Drepanosira Bonet
   – Mucro bidentate, Mucronal basal spine absent, Scales absent on Man, Abd II–III with dark blue pigment, at least partly. ..................................................Willowsia bartkei Stach, 1965

25. Ocelli 8+8, on large ocellar spots, (Lepidocyrtus Bourlet); Head with Mac S and T present between the eyes. ............L. lanuginosus (Gmelin, 1788)
   – Ocelli 0–4 on each side, ocellar spots small or absent (Pseudosinella Schaffer); Ocelli 4+4, Th 2 with one posterior Mac. ..................................................P. octopunctata (Böner, 1901)

DISCUSSION

During this study, belonging to twenty-two genera and five families of order Entomobryomorpha were identified, which are listed in Table 1. In the studies of Iranian Collembola fauna conducted from 2013 to 2021, most reported collembolan species were collected only from Guilan, Golestan, Kermanshah, and Mazandaran provinces (Shayanmehr et al., 2020a). However, because of the vast area and great variations in terms of climate and other environmental conditions, the springtail fauna of many parts of the country has not been yet explored. Previously 105 species belonging to six families and 34 genera of order Entomobryomorpha had been reported from Iran (Shayanmehr et al., 2020c). Of the total species of order Entomobryomorpha in Iran, the family Isotomidae with 21 genera and 56 species contains 52%, followed by family Entomobryidae with 10 genera and 34 species (31%), family Orchesellidae with 3 genera and 9 species (8%), family Tomoceridae with three genera and four species (4%), family Paronellidae with one genus and 3 species (3%) and Oncopoduridae with 1 genus and 2 species (2%) (Fig. 7).

Iran mainly belongs to the Palearctic biogeographic realm, but southern part of the country is affected by the Afrotropical realm. Folsomia penicula, H. pontica, I. graminis, E. corticalis, H. variabilis and D. lussi that are among the identified species are distributed in the Palearctic realm. Folsomia quadrioculata, I. minor, I. viridis, L. lanuginosus, O. cincta and O. flavescens (Bourlet, 1839) are among those considered as holarctic species. Also, the species including D. trispinata, P. notabilis, F. parvulus, H. nitidus, P. octopunctata and T. vulgaris are distributed in the cosmopolitan realm. Except for P. octopunctata and O. cincta that collected from mosses on the rock, most of the species reported from Iran have been collected from the soil and leaf litter of trees such as Quercus sp. and Morus sp., Prunus sp., Pinus sp., Platanus sp., Ulmus sp., Cupressus sp., Ailnus sp., Parrotia persica (CA Meyer) and alfalfa fields. Unlike S. atlantica, which is herbivorous species and has the potential to become a pest in alfalfa fields and cause damage to crops, all species found in this study feed on organic matter, bacteria, fungal hyphae and spores in the litters.
Some species were found in only one ecosystem, and some lived in a variety of ecosystems. For example, *H. variabilis*, *D. hussi*, *W. bartkei*, *F. penicula*, *Heteromurtrella* sp., *D. trispinata*, *T. vulgaris*, *Cyphoderus* sp. and *H. pontica* were collected only from the forest ecosystem. Several species i.e. *O. flavescens*, *I. viridis*, *I. graminis*, *F. parvulus* and *I. gracilimucronata* were found from the rangelands and *S. atlantica* and *Agrenia* sp. were found from the agricultural ecosystem. Also, the species *E. corticalis*, *Sinella* sp., *Parisotoma* sp., *H. nitidus*, *P. octopunctata* and *L. lanuginosus* studied here can be found in all three ecosystems.

Very few studies have been conducted on springtails fauna in the neighboring countries of Iran e.g., Pakistan, Armenia, and Iraq (Yosii & Ashraf, 1964; Yosii, 1966; Ashraf, 1970; Rusek, 1981). In recent years publications by Jordana et al. (2011) in Armenia (two species), Sevgili & Özata (2014) and Özata et al. (2017) in Turkey (29 species), and Abdul-Rassoul (2021) in Iraq (33 species) have added to much more data to springtails fauna of Iran’s neighboring countries. Common species reported so far from Iran's neighboring countries are as follows: *F. parvulus*, *F. penicula*, *I. gracilimucronata*, *I. minor*, *I. viridis*, *P. notabilis* from Isotomidae family, *H. nitidus*, *L. lanuginosus* and *P. octopunctata* from family Entomobryidae. *I. gracilimucronata* has previously been reported only from Iraq, while this species is reported for the first time from Iran. *S. atlantica* Negri et al. 2005 was also collected for the first time in Morocco and is now identified in Iran (Shayanmehr et al., 2020a). Because of the different climatic regions and various ecosystems in Iran and the fact that many parts of the country is still unexplored in terms of soil faunistic studies, it would be expected that a large number of springtails be discovered after some further studies in the future.
Table 1. Family, Subfamily, species, habitat and distribution of Entomobryomorpha order species recorded in the North Khorasan province, Iran.

<table>
<thead>
<tr>
<th>Family</th>
<th>Subfamily</th>
<th>Collembola Species</th>
<th>Habitat</th>
<th>Presence or absence in the ecosystem</th>
<th>Sampling area (Province)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entomobryidae</td>
<td>Entomobryinae</td>
<td>Drepanura sp.</td>
<td>soil and leaf litter</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Entomobryidae</td>
<td>Entomobryinae</td>
<td>Entomobrya corticalis (Nicolet, 1841)</td>
<td>soil and leaf litter</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Entomobryidae</td>
<td>Entomobryinae</td>
<td>Sinella sp.</td>
<td>soil of alfalfa field</td>
<td>-</td>
<td>+</td>
</tr>
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<td>Entomobryidae</td>
<td>Entomobryinae</td>
<td>Dresanosina hussi</td>
<td>soil and leaf litter</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Entomobryidae</td>
<td>Entomobryinae</td>
<td>Willowsia bartkei</td>
<td>soil and leaf litter</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Entomobryidae</td>
<td>Lepidocyrtinae</td>
<td>Drepanoclytus lanuginosus (Gmelin, 1788)</td>
<td>soil and leaf litter</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Entomobryidae</td>
<td>Lepidocyrtinae</td>
<td>Willowsia bartkei</td>
<td>soil and leaf litter</td>
<td>-</td>
<td>-</td>
</tr>
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<td>Entomobryidae</td>
<td>Seirinae</td>
<td>Seira atlantica</td>
<td>soil of alfalfa field</td>
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<td>-</td>
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<tr>
<td>Orchesellidae</td>
<td>Heteromurinae</td>
<td>Heteromurtrella sp.*</td>
<td>soil and leaf litter</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Orchesellidae</td>
<td>Heteromurinae</td>
<td>Heteromurus nitidus (Templeton, 1835)</td>
<td>soil and leaf litter</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Orchesellidae</td>
<td>Heteromurinae</td>
<td>Heteromurus variabilis (Martynova, 1974)</td>
<td>soil and leaf litter</td>
<td>-</td>
<td>-</td>
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<td>Orchesellidae</td>
<td>Orchesellinae</td>
<td>Orchesella cincta</td>
<td>leaf litter and moss on the rock</td>
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<td>+</td>
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<td>Orchesellidae</td>
<td>Orchesellinae</td>
<td>Orchesella flavescens (Bourlet, 1839)*</td>
<td>soil and leaf litter</td>
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<td>+</td>
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<tr>
<td>Isotomidae</td>
<td>Anurophorinae</td>
<td>Folsomia penicula</td>
<td>soil (Quercus sp.) and leaf litter under oak trees</td>
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<td>-</td>
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<td>Isotomidae</td>
<td>Anurophorinae</td>
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<td>soil and leaf litter</td>
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<td>Hemisotoma pontica (Stach, 1947)</td>
<td>soil</td>
<td>+</td>
<td>-</td>
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<td>Isotomidae</td>
<td>Anurophorinae</td>
<td>Isotomiscella graecilimucronata Rusek, 1981*</td>
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<td>+</td>
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<td>+</td>
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<td>Isotominae</td>
<td>Agrenia sp.*</td>
<td>soil of alfalfa field</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Isotomidae</td>
<td>Isotominae</td>
<td>Desoria trispinata (MacGillivray, 1896)*</td>
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<td>Isotoma sp.</td>
<td>soil of alfalfa field</td>
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<tr>
<td>Isotomidae</td>
<td>Isotominae</td>
<td>Isotomurus graminis</td>
<td>soil</td>
<td>-</td>
<td>+</td>
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</table>
Table 1. Countinued.

<table>
<thead>
<tr>
<th>Family</th>
<th>Subfamily</th>
<th>Collembola Species</th>
<th>Habitat</th>
<th>Presence or absence in the ecosystem</th>
<th>Sampling area (Province)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isotomidae</td>
<td>Isotominae</td>
<td>24 Isotomurus sp.</td>
<td>soil of alfalfa field</td>
<td>+</td>
<td>North Khorasan</td>
</tr>
<tr>
<td>Isotomidae</td>
<td>Isotominae</td>
<td>25 Parisotoma notabilis (Schäffer, 1896)</td>
<td>soil and leaf litter</td>
<td>+</td>
<td>Golestan, Guilan, Kerman, Kermanshah, Khuzestan, Lorestan, Mazandaran, North Khorasan, Tehran, West Azarbaijan, Zanjan</td>
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<td>Isotomidae</td>
<td>Isotominae</td>
<td>26 Parisotoma sp.</td>
<td>soil and leaf litter</td>
<td>+</td>
<td>North Khorasan</td>
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<tr>
<td>Isotomidae</td>
<td>Proisotominae</td>
<td>27 Folsomides parvulus Stach, 1922</td>
<td>soil and leaf litter</td>
<td>-</td>
<td>East Azarbaijan, Guilan, Kerman, Kermanshah, Lorestan, Mazandaran, North Khorasan, Semnan, Tehran, West Azarbaijan</td>
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<td>Cyphoderidae</td>
<td>Cyphoderinae</td>
<td>28 Cyphoderus sp.</td>
<td>soil and leaf litter</td>
<td>-</td>
<td>North Khorasan</td>
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<tr>
<td>Tomoceridae</td>
<td>Tomoceridae</td>
<td>29 Tomocerus vulgaris (Tullberg, 1871)</td>
<td>soil and leaf litter</td>
<td>+</td>
<td>East Azarbaijan, Guilan, Kerman, Kermanshah, Mazandaran, North Khorasan, Zanjan</td>
</tr>
</tbody>
</table>

AUTHOR’S CONTRIBUTION

The authors confirm contribution in the paper as follows: M. Mehrafrooz Mayvan performed the experiments and analyzed the results and wrote the manuscript; H. Sadeghi-Namaghi designed and supervised the study; M Shayanmehr and P. Greenslade participated in species identification and manuscript editing. All authors approved the final version of the manuscript.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper.

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REFERENCES


گزارش‌های جدید از پادمان راسته‌ی Entomobryomorpha ایران به همراه کلیدشناسایی گونه‌ها

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چکیده: پادمان خاکزی راسته‌ی Entomobryomorpha برای اولین بار در شرق ایران به عنوان بخشی از یک مطالعه تنوع زیستی با هدف بهبود حفاظت از زیست‌بوم بررسی شدند. پادمان این راسته با نمونه‌برداری از سه زیست‌بوم مختلف شامل جنگل، مرتع و مزرعه کشاورزی بین سال‌های 1397 تا 1398 به‌دست آمد. نمونه‌ها با استفاده از مایع نسیبی با اسید لاکتیک و یونگ شند اصلاح‌های میکروسکوپی دایمی با استفاده از محیط هوریب تهیه شد. در نتیجه این مطالعه، 26 گونه متعلق به 22 جنس و 5 خانواده از راسته‌ی Entomobryomorpha شناسایی شد. از این میان Desoria Drepanosira hussi Neuherz, 1976, trispinata (MacGillivray, 1896) Willowsia , Orchesella flavescens (Bourlet, 1839), Heteromurtrella sp. Isotomiella gracilinucronata Rusek, و Agrenia sp. bartkei Stach, 1965

1398 بودند. ویژگی‌های مهم افتراقی و کلید شناسایی گونه‌ها نیز ارائه شد.

واژگان کلیدی: فهرست پادمان، کشاورزی، جنگل، جمعیت پادمان

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