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Symphypleon springtails (Collembola: Symphypleona) from Iran with a checklist and a key to the Symphypleon springtails of Iran and redescription of one new species record for Iran Collembola fauna

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Abstract

The Symphypleon springtails collected from Guilan province in Northern Iran were investigated in the framework of a faunal study that carried out between 2009 and 2011. Among totally 25 determined species of Collembola in this study, three species and one tribe of order Symphypleona were reported for the first time from Guilan province, Iran. Of these, *Stenacidia violacea* (REUTER, 1881) is a new record for the Symphypleon fauna of Iran. In total, 22 species of Symphypleon springtails were identified by different authors until May 2018 from Iran. This paper tries to introduce an updated outlook of Symphypleon springtails of Iran with presenting a checklist and an identification key for Symphypleon springtails of Iran. Detailed description of *Stenacidia violacea* is also provided based on the material collected from Guilan province, Iran.

K e y w o r d s : Collembola; Symphypleona; fauna; *Stenacidia violacea*; Iran

Zusammenfassung

Die aus der Provinz Guilan im Norden Irans gesammelten Symphypleon-Springschwänze wurden im Rahmen einer zwischen 2009 und 2011 durchgeführten Faunenstudie untersucht. Unter insgesamt 25 bestimmten Collembolen-Arten wurden in dieser Studie drei Arten und ein Stamm der Ordnung Symphypleona erstmals für die Provinz Guilan, Iran, aufgeführt. Von diesen ist *Stenacidia violacea* (REUTER, 1881) ein neuer Eintrag für die Symphypleon-Fauna des Iran. Insgesamt wurden 22 Arten von Symphypleon-Springschwänzen von verschiedenen Autoren bis Mai 2018 aus dem Iran identifiziert. Diese Arbeit versucht, eine aktualisierte Ansicht von Symphypleon-Springschwänzen des Iran mit einer Checkliste und einem Identifikationsschlüssel einzuführen. Eine detaillierte Beschreibung von *Stenacidia violacea* wird ebenfalls anhand des Materials aus der Provinz Guilan, Iran, bereitgestellt.

Introduction

Collembola, numerically, are most dominant hexapoda in terrestrial ecosystems and are widely distributed worldwide with a wide range of habitats. They are considered as entognathous with mouthparts inside the buccal cavity and wingless hexapods. They mostly live in the soil or leaf litter of gardens, arable fields and forests and most of them feed on decaying plant material, fungi and bacteria. Just few species of Collembola are already distinguished as pest in alfalfa farms, greenhouses and center of mushroom nursery. They have great importance in the soil ecosystem by functioning as key soil decomposer group that regulate nutrient cycling and affect soil fertility and water retention in the soil. Overall, Collembola with their high diversity are qualified for bioindication of terrestrial ecosystem processes like successional dynamics. According to BELLINGER et al. (1996-2018), Collembola are currently classified into four orders: Poduromorpha BÖRNER, 1913; Entomobryomorpha BÖRNER, 1913; Symphypleona BÖRNER, 1901; Neelipleona MASSOUD, 1971. The taxon Symphypleona BÖRNER, 1901 is a monophylum of class Collembola with two diagnostic characteristics; plesiomorphies (Furca and Retinaculum always present and well developed) and apomorphies (Furca and Retinaculum more or less reduced). This taxon is known by globular structure of the body of specimens, in which the thoracic and abdominal segments are fused. According to BRETTFELD (1999), the total length of Symphypleon adults are from 0.12 mm to 4 mm. In general, their body is divided into three tagma: head (first tagma), thorax I-III fused with abdomen I-IV (second tagma), abdomen V and VI (third tagma). Most of the species in this taxon are pigmented in different colors presented with variety of spots or longitudinal or cross stripes. The state of pigmentation, the transformed setae such as bothriotrichia, postantennal setae, neosminthuroid setae at the furca basis and female appendices anales on the ventral anal valves are considered as important factors in species determination of Symphypleon springtails. The plesiomorphically forms live in moist habitats like on the surface of fresh waters and the apomorphically forms live in dry habitats mostly on the soil and litter surface, on trees, on dry and sunny grounds, in intertidal zones and in caves (BRETTFELD 1999).

Symphypleon springtails need to be studied in detail because of their small body size and definition of chaetotaxy (arrangement of setae) that all makes difficulty in their proper determination into species level. Especially, Symphypleon springtails of Iran are mostly unknown and the present knowledge of this group should be improved with distinguishing the defined Iranian species and providing an updated identification key for Iranian known Symphypleon species. Until now 22 Symphypleon springtail species were determined and recorded from different parts of Iran (FARRAHBAKHSH 1961; COX 1982; DAGHIGHI 2012; KAHRARIAN et al. 2012; YAHYAPOUR 2012; DAGHIGHI et al. 2013; FALAHATI HOSSEIN ABAD et al. 2013; GHAHRAMANINEZHAD et al. 2013; SHAYANMEHR et al. 2013; BAKHSHI et al. 2014; YOOSEFI LAFOORAKI & SHAYANMEHR 2015; MAYVAN et al. 2015; QAZI & SHAYANMEHR 2016). In this study, 25 Collembola species from 27 genera and 11 families were identified from Guilan province. Among identified species, three species belonging to the order Symphypleona. Of these, one species *Stenacidia violacea* (REUTER, 1881) is reported for the first time from Iran. The Collembola fauna of Iran, except some regions of Iran such as Guilan, Mazandaran, Golestan, East Azarbaijan, Tehran, Markazi, Kermanshah and Kohgiluyeh provinces, is poorly studied and it is still unknown for most parts of Iran. This issue is

more perceptible in the order Symphypleona of the class Collembola. Therefore, the aim of this paper is to improve the knowledge about Symphypleon springtails of Iran by presenting an updated checklist and a key for identified Symphypleon springtails from Iran. Thereby, the outcome of this paper encourages the scientific researchers in the field of entomology to direct their researches towards the faunistic studies of Collembola (specifically Symphypleona) with their high functionality in ecosystems in Iran.

Material and Methods

This study was conducted in Rasht and suburbs in Guilan province, Iran (Mediterranean climate, average temperature 16°C, average precipitation 1255.5 mm; Köppen climate classification). Soil and litter samples were collected from different habitats such as fields, gardens, forests and parks between 2009 and 2011. Each soil sample contained about 2 kg soil that was taken to a depth of 15 cm. Thereafter, microarthropods were extracted from soil samples by Berlese funnel. Specimens of springtails were sorted and preserved in Ethanol 70%. Specimens were cleared in Nesbitt's fluid and mounted permanently on microscope slides using Hoyer's medium. The springtails were identified by the relevant taxonomic keys and papers (BEI-BIENKO 1967; BRETTFELD 1999; FJELLBERG 2007). For precise inspection of morphological characters of prepared specimens, a compound microscope equipped with differential interference contrast and phase contrast optical system and a drawing tube (Olympus BX51, Olympus Optical Co., Ltd, Tokyo, Japan) was used. Some specimens of Symphypleon springtails were sent to Dr. Jean-Marie Betsch [1939-2013] (Muséum National d'Histoire Naturelle (MNHN), Department of Ecology and Management of Biodiversity, Brunoy, France) for confirmation. The voucher material which comprises slide mounted specimens are deposited in the Department of Plant Protection at University of Guilan, Rasht, Iran.

Results and discussion

The updated number of Symphypleon springtails of Iran reported until May 2018 is 22 species belonging to 10 genera and 5 families. An alphabetical list (checklist) of recorded species in Iran according to the recent classification provided by BELLINGER et al. (1996-2018) accompanying details of species collection is provided (Table 1). Most of the recorded Symphypleon species from Iran belong to the family Katiannidae with 31.82%, followed by families Sminthuridae (27.27%), Sminthurididae and Dicyrtomidae (18.18%) and Arrhopalitidae (4.55%) (Fig. 1). In this study, a total of three species and one tribe belonging to the order Symphypleona were collected and determined from Guilan province, Iran. All of them recorded for the first time from Guilan province; of these, one species (*Stenacidia violacea*) recorded for the first time from Iran.

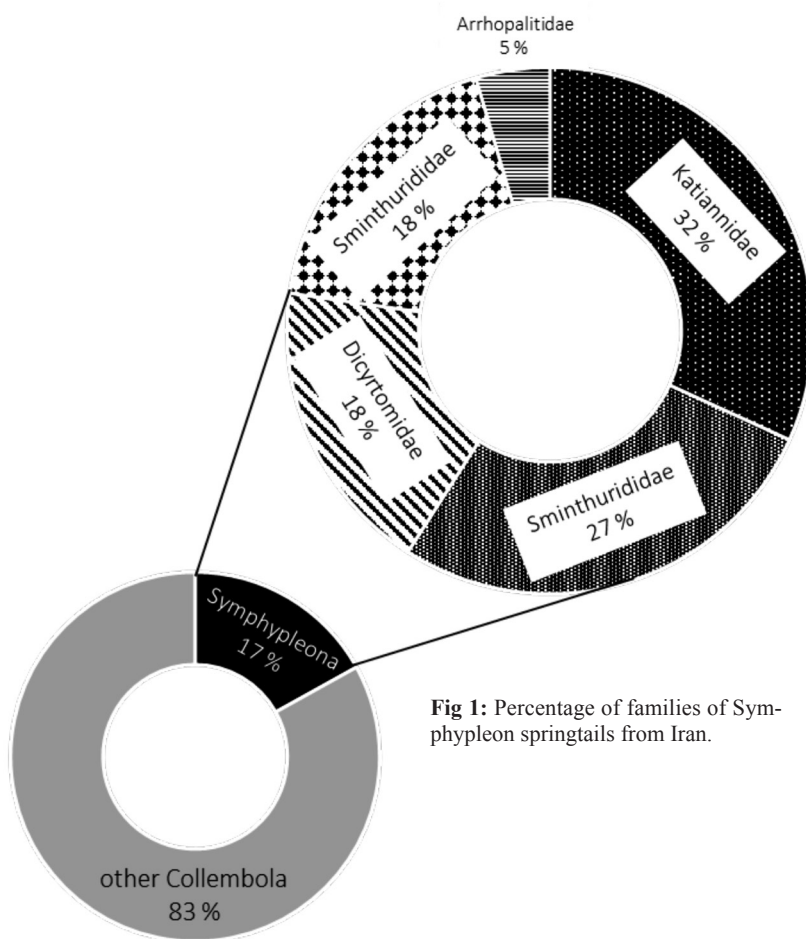


Fig 1: Percentage of families of Symphyleon springtails from Iran.

Table 1: Checklist of Symphyleon springtails (Collembola: Symphyleona) from Iran.

No.	Species	Reference	Sampling area
1	<i>Allacma fusca</i> STACH, 1956	BAKSHI et al. 2014	Mazandaran
2	<i>Arrhopalites caecus</i> (TULLBERG, 1871)	COX 1982; GHAHRAMANINEZHAD et al. 2013; SHAYANMEHR et al. 2013	Guilan, East Azarbaijan, Kermanshah
3	<i>Caprainea marginata</i> (SCHÖTT, 1893)	KAHRARIAN et al. 2012; SHAYANMEHR et al. 2013; MAYVAN et al. 2015	Kermanshah
4	<i>Dicyrtoma (Dicyrtomina) minuta</i> (FABRICIUS, 1783)	COX 1982	Mazandaran, Guilan

No.	Species	Reference	Sampling area
5	<i>Dicyrtoma cf. ghilarovi</i> BRETTFELD, 1996	MAYVAN et al. 2015	Mazandaran
6	<i>Dicyrtoma fusca</i> LUBBOCK, 1873	YAHYAPOUR 2012; SHAYANMEHR et al. 2013	Mazandaran
7	<i>Dicyrtomina ornata</i> NICOLET, 1842	YAHYAPOUR 2012; SHAYANMEHR et al. 2013	Mazandaran, Kohgiluyeh and Boyer-Ahmad
8	<i>Lipothrix LUBBOCKI</i> (TULLBERG, 1872)	MAYVAN et al. 2015	Mazandaran
9	<i>Sminthurides aquaticus</i> (BOURLET, 1842)	FALAHATI HOSSEIN ABAD et al. 2013	Kohgiluyeh and Boyer-Ahmad
10	<i>Sminthurides malmgreni</i> (TULLBERG, 1876)	COX 1982; SHAYANMEHR et al. 2013; QAZI & SHAYANMEHR 2016	Markazi, Guilan, East Azarbaijan, Tehran
11	<i>Sminthurinus aureus</i> LUBBOCK, 1862	YAHYAPOUR 2012; DAGHIGHI 2012; DAGHIGHI et al. 2013	Guilan, Mazandaran
12	<i>Sminthurinus bimaculatus</i> (AXELSON, 1902)	COX 1982; SHAYANMEHR et al. 2013	Guilan
13	<i>Sminthurinus elegans</i> FITCH, 1863	COX 1982; YAHYAPOUR 2012; FALAHATI HOSSEIN ABAD et al. 2013; GHAHRAMANINEZHAD et al. 2013; SHAYANMEHR et al. 2013; MAYVAN et al. 2015; YOOSEFI LAFOORAKI & SHAYANMEHR 2015	Mazandaran, Golestan, Kermanshah, Kohgiluyeh and Boyer-Ahmad
14	<i>Sminthurinus gisini</i> GAMA, 1965	YOOSEFI LAFOORAKI & SHAYANMEHR 2015	Mazandaran
15	<i>Sminthurinus reticulatus</i> CASSAGNAU, 1964	FALAHATI HOSSEIN ABAD et al. 2013	Kohgiluyeh and Boyer-Ahmad
16	<i>Sminthurinus signatus</i> (KRAUSBAUER, 1898)	FALAHATI HOSSEIN ABAD et al. 2013	Kohgiluyeh and Boyer-Ahmad
17	<i>Sminthurinus transvernalis</i> AXELSON, 1905	FALAHATI HOSSEIN ABAD et al. 2013	Kohgiluyeh and Boyer-Ahmad
18	<i>Sminthurus cf. ghilarovi</i> STEBAEVA, 1966	MAYVAN et al. 2015	Mazandaran
19	<i>Sminthurus cf. nigromaculatus</i> TULLBERG, 1871	GHAHRAMANINEZHAD et al. 2013; YOOSEFI LAFOORAKI & SHAYANMEHR 2015	Mazandaran, Kermanshah
20	<i>Sminthurus viridis</i> LINNAEUS, 1758	FARRAHBAKSH 1961; SHAYANMEHR et al. 2013	Khuzestan
21	<i>Sphaeridia pumilis</i> (KRAUSBAUER, 1898)	COX 1982; KAHRARIAN et al. 2012; YOOSEFI LAFOORAKI & SHAYANMEHR 2015; QAZI & SHAYANMEHR 2016	Markazi, Guilan, Kermanshah, Tehran
22	<i>Stenacidia violacea</i> (REUTER, 1881)	DAGHIGHI 2012	This study (Guilan)

Key to families, genera and species of Symphypleon springtails from Iran

1. Ocelli six or more per side of head, darker species 2
 - Ocelli two or fewer per side of head, paler species (Arrhopalitidae)
Arrhopalites caecus (TULLBERG, 1871)
2. Males with modified Ant (Antennae) II and III, females without sub-anal appendages Sminthuridae 3
 - Males without modified Ant II and III, females with various forms of sub-anal appendages 6
3. Tibiotarsal organ present (inner side of tibiotarsus III) 4
 - Tibiotarsal organ absent *Sphaeridia pumilis* (KRAUSBAUER, 1898)
4. Posterior large abdomen dorsally with 6-8 pairs of long setae close together
Stenacidia violacea (REUTER, 1881)
 - Posterior large abdomen without such setae Sminthuridae 5
5. Mucro broader and at least $\frac{1}{2}$ as wide as long, ventral tube with smooth sacs, retinaculum with 3-4 setae *Sminthurides aquaticus* (BOURLET, 1842)
 - Mucro narrower and only $\frac{1}{3}$ as wide as long, ventral tube with smooth and conical sacs, retinaculum with 2-3 setae
Sminthurides malmgreni (TULLBERG, 1876)
6. Ant IV much shorter than Ant III Dicyrtomidae 7
 - Ant IV longer than or equal to Ant III 10
7. Dorsal head-back with setal pairs 1+2 (or 1-3) modified to long spines, claws with tunica Dicyrtomina 8
 - Dorsal head-back with only setal pair 1 modified to slender spines, claws without tunica Dicyrtoma 9
8. Large abdomen without or with light violet pigmentation
Dicyrtomina minuta (FABRICIUS, 1873)
 - Large abdomen laterally with dark violet pigmentation and with irregular, bluish black longitudinal and cross stripes *Dicyrtomina ornata* NICOLET, 1842
9. Ratio of setae E3:E2 of dens about 1 (Dens with rough or serrate setae thickened basally) *Dicyrtoma ghilarovi* BRETTFELD, 1996
 - This ratio more than or equal to 3 (Dens with rough or serrate setae thickened basally) *Dicyrtoma fusca* LUBBOCK, 1873
10. Neosminthuroid setae present, abdomen dorsally without distinct macrosetae, Ant IV not subdivided (simple) Katiannidae (Sminthurinus) 11
 - Neosminthuroid setae missing, abdomen dorsally with many macrosetae, Ant IV subdivided Sminthuridae (Sminthurinae) 17

11. Dens anteriorly without subapical setae, dens posteriorly with 1 outer subapical and 3 proximal setae, inner edge of mucro serrate and outer smooth12
 - Dens anteriorly with at least 1 subapical setae, dens posteriorly with 2 outer subapical and 4 proximal setae, inner and outer edges of mucro serrate*Sminthurinus gisini* GAMA, 1965
12. Large abdomen without or with only diffuse dark pigment*Sminthurinus aureus* LUBBOCK, 1862
 - Large abdomen with dark pigment13
13. Large abdomen with 1 posterolateral pair of large white spots*Sminthurinus bimaculatus* (AXELSON, 1902)
 - Large abdomen without such spots14
14. Large abdomen with clear cut dark and only longitudinal stripes*Sminthurinus elegans* FITCH, 1863
 - Large abdomen without clear cut dark15
15. Abdomen only with a single lateral band present, no dorsal bands*Sminthurinus signatus* (KRAUSBAUER, 1898)
 - Abdomen with anterior dorsal zigzags and posterior mid-dorsal band16
16. Mid-section of head posteriorly without pigment*Sminthurinus transversalis* AXELSON, 1905
 - Mid-section of head dark back to posterior and large abdomen with irregular cross stripes*Sminthurinus reticulatus* CASSAGNAU, 1964
17. Posterior edges of mucro serrate18
 - Posterior edges of mucro smooth or wavy19
18. Claws with tunica and cavity*Sminthurus ghilarovi* STEBAEVA, 1966
 - Claws with or without tunica and cavity20
19. SubCoxa III with 1 (short) distal setae, ventral tube with 1+1 setae*Sminthurus viridis* LINNAEUS, 1758
 - SubCoxa III with 2 (short and long) distal setae, ventral tube with 2+2 setae*Sminthurus nigromaculatus* TULLBERG, 1871
20. Dens with more than and equal to 9 ventral setae, thorax II without finger-like vesicles21
 - Dens with less than and equal to 6 ventral setae, thorax II with finger-like vesicles*Lipothrix lubboki* (TULLBERG, 1872)
21. Head with a short thick setae between base of antennae and eye field (postantennal setae)*Allacma fusca* STACH, 1956
 - Head frons without such setae*Caprainea marginata* (SCHÖTT, 1893)

List of species of Symphypleon springtails in Guilan province, Iran

Family S m i n t h u r i d i d a e BÖRNER, 1906

***Sphaeridia pumilis* (KRAUSBAUER, 1898)**

S y n o n y m s (after BRETTFELD 1999):

Sminthurus pumilis KRAUSBAUER, 1898: 495

Sminthurides pumilio BÖRNER, 1901: 138

Sminthurides globosus AXELSON, 1902: 109

Sminthurides pumilis AXELSON, 1907: 133

Sphaeridia pumilio AGRELL, 1934: 233

Sminthurides (Sphaeridia) minimus (SCHÖTT, 1893 a) sensu PACLT, 1959: 63

B o d y s i z e a n d c o l o r : Total length between 0.25 and 0.5 mm. Their body color is pinky or pale yellow and sometimes with little blue pigments.

M a t e r i a l e x a m i n e d : 3 females, Iran, Guilan province, Rasht, 4 m, 37°16'51"N, 49°34'59"E, 24 March 2010, soil under buttonwood tree, collected by E. DAGHIGHI.

D i s t r i b u t i o n : Palaearctic region including Iran (COX 1982; DAGHIGHI 2012; KAH-RARIAN et al. 2012; YOOSEFI LAFOORAKI & SHAYANMEHR 2015; QAZI & SHAYANMEHR 2016; Table 1), Russia (BEI-BIENKO 1967), Algeria, Italy, Germany, Sweden (BRETTFELD 1999), Scandinavia (FJELLBERG 2007), Poland (RZESZOWSKI & STERZYŃSKA 2016), Australasia region including Australia (BRETTFELD 1999), Neotropic region including Brazil (BRITO et al. 2017).

***Stenacidia violacea* (REUTER, 1881)**

S y n o n y m s (after BRETTFELD 1999):

Sminthurus violaceus REUTER, 1881: 203

Sminthurus (Sminthurides) violaceus BÖRNER, 1900: 616

Sminthurides violaceus BÖRNER, 1901: 98

Sminthurides (Stenacidia) violaceus BÖRNER, 1906: 182

Sminthurides (Stenacidia) STACHI JEANNENOT, 1955:1

Jeannenotia STACHI STACH, 1956:10

Jeannenotia STACHI australiensis BETSCH & MASSOUD, 1970: 173

B o d y s i z e a n d c o l o r : details can be found below.

M a t e r i a l e x a m i n e d : 4 females, Iran, Guilan province, Rasht (University of Guilan), 27 m, 37°11'55.03"N, 49°38'33.58"E, 11 November 2009, soil under cedar tree; Sangar, 27 m, 37°09'71"N, 49°41'54"E, 8 April 2011, soil under plum tree, collected by E. DAGHIGHI.

D i s t r i b u t i o n : Palaearctic region including Iran (DAGHIGHI 2012; Table 1), Russia (BEI-BIENKO 1967), Finland (FJELLBERG 2007).

R e m a r k s : this species is recorded for the first time from Iran.

Family KATIANNIDAE BÖRNER, 1913

Sminthurinus aureus (LUBBOCK, 1862)

Synonyms (after BRETTFELD 1999):

Smynthurus aureus LUBBOCK, 1862: 589

Metakatianna anglicana SALMON, 1955: 242, GISIN, 1960: 279

Body size and color: Total length is 1 mm. Their body is differently colored, black, brown and yellow with eye spots. Body without distinct pattern.

Material examined: 6 females, 4 males, Iran, Guilan province, Rasht, 4 m, 37°16'51"N, 49°34'59"E, 11 November 2009 and 9 April 2010, soil under cedar and acacia tree; Sangar, 27 m, 37°09'71"N, 49°41'54"E, 11 August 2010 and 8 April 2011, soil under spruce and plum tree; Khoshk-e Bijar, -14 m, 37°22'29"N, 49°45'27"E, 17 September 2010, soil under elves tree; Pasikhan, -3 m, 37°16'21.83"N, 49°28'02.46"E, 27 August 2010, soil under maple tree; Saravan, 60 m, 37°07'41.08"N, 49°39'57.32"E, 21 April 2011 soil of the river side, collected by E. DAGHIGHI.

Distribution: Palaearctic region including Iran (YAHYAPOUR 2012; DAGHIGHI 2012; DAGHIGHI et al. 2013; Table 1), Russia (BEI-BIENKO 1967), England, Japan, Madeira and the Azores, Morocco, Portugal (BRETTFELD 1999), Scandinavia (FJELLBERG 2007), Poland (RZESZOWSKI & STERZYŃSKA 2016).

Family Dicyrtomidae BÖRNER, 1906

Dicyrtomini sp.

Body size and color: Total length between 1-3 mm. Their body surface is generally yellow with blue spots on top of abdomen.

Material examined: 2 juveniles, Iran, Guilan province, Rasht, 4 m, 37°16'51"N, 49°34'59"E, 9 April 2010, soil under cedar tree, collected by E. DAGHIGHI.

Distribution (all reported species belong to this group): Palaearctic region including Iran (COX 1982; DAGHIGHI 2012; YAHYAPOUR 2012; SHAYANMEHR et al. 2013; MAYVAN et al. 2015; Table 1), Russia (BEI-BIENKO 1967; BRETTFELD 1999), Algeria, Azerbaijan, England, France, Ireland, Italy, Madeira and the Azores, Morocco, N Africa, Portugal, Serbia (BRETTFELD 1999), Scandinavia (FJELLBERG 2007).

Remarks: according to the condition of available specimens of this group of Symphyleon springtails collected from Guilan province, Iran, it was not possible to identify them to genus and species level. Therefore, they were only determined to tribe level.

Description of newly recorded species *Stenacidia violacea* (REUTER, 1881) for Iran

Body size and color (Fig. 2): Total length between 0.5 and 0.7 mm. Females are bigger than males. Their body surface has a yellow background and is covered by pink and violet pigments, which is paler into the tip of abdomen.

Eyes (Fig. 2): 8+8 ocelli on each side of the head. Eyes C and D smaller than A, B, E, F, G, H.

Antennae (Fig. 3): Antenna (Ant II and III) of male is modified and formed a peculiar organ to grasp the female during copulation. The Ant II bears a long curved spine. Ant III and IV bears some long visible hairs on ventral side. Ant III and IV in females with 2 and 3 large, blunt setae respectively. Ant IV in both sexes not segmented.

Mouthparts (Fig. 4): Maxilla with short lamellae.

Tibiotarsi (Fig. 5): Posterior legs with tibiotarsal organ on ventral side; about $\frac{1}{2}$ as long as claw. Males with several long, ciliate outer setae on tibiotarsi III.

Claws (Fig. 5): Claws with inner tooth, 2 pairs of lateral teeth, few outer teeth, and tunica. Empodium is shorter (about $\frac{1}{2}$) than claw. Males have a longer claw III than the others.

Abdomen (Fig. 2): Posterior part of large abdomen with rows of long hairs.

Dens (Fig. 6): Dens with relatively few setae containing 4 inner spine like setae and 8-10 outer normal setae.

Mucro (Fig. 7): Mucro is long and narrow without lamellae. It is narrowed ventrally to the tip of mucro. The inner plate of mucro has numerous denticles, but the outer dorsal plate is smooth. Mucro bears narrow crests.

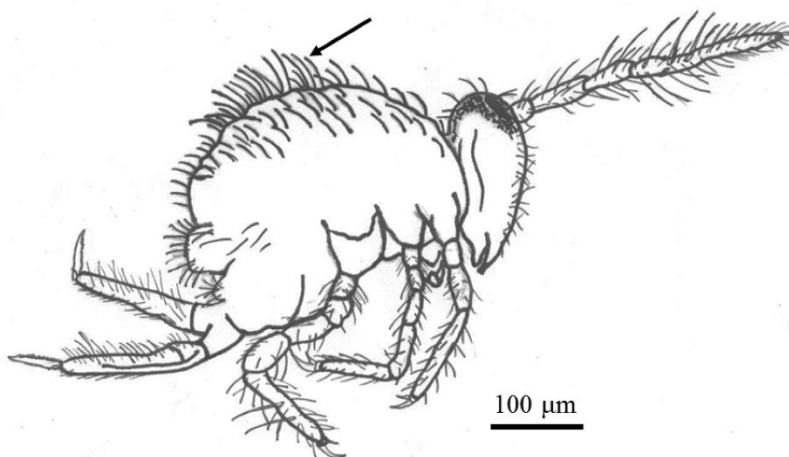
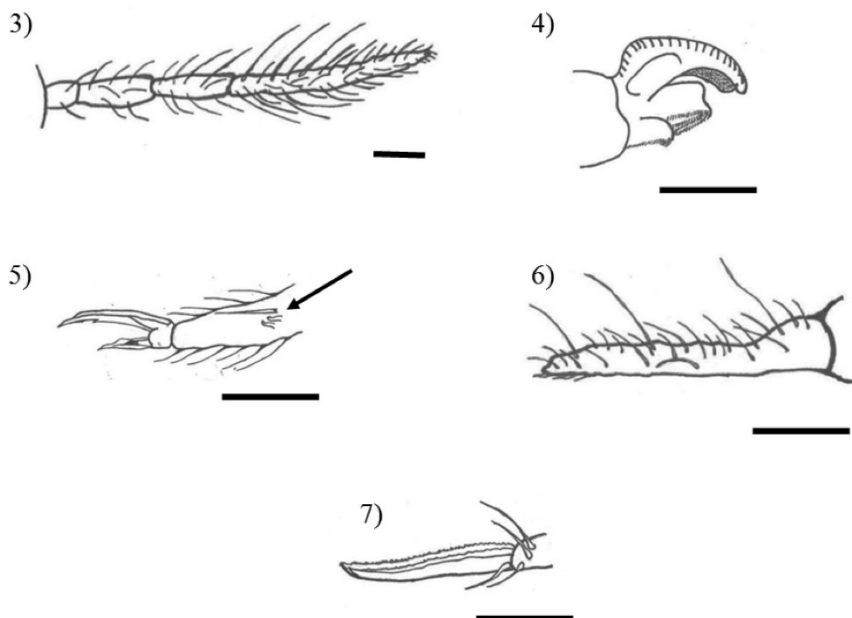


Fig 2: *Stenacidia violacea*: general picture; rows of long hairs on dorsal part of abdomen are shown by one arrow.



Figs 3-7: *Stenacidia violacea*: (3) simple antenna defined in female, (4) mouthpart: maxilla, (5) claw and empodium; tibiotarsal organ is shown by one arrow, (6) dens, (7) mucro. All scale bars are 50 μm .

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