Zoogeography and Faunistics
Research Article

ACTA ZOOLOGICA BULGARICA
Acta zool. bulg., 70 (3), 2018: 309-314

The Giant Springtail *Tetrodontophora bielanensis* (Waga, 1842) (Hexapoda: Collembola) – New to the Fauna of Bulgaria

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Abstract: The giant springtail *Tetrodontophora bielanensis* (Waga, 1842) has been collected from the Ruy Mountain, West Bulgaria. The present record is the first for this species from Bulgaria. The species is illustrated and for the first time morphological abnormalities in this genus are described. Zoogeographical notes and comments on the conservation status of the species are provided.

Key words: *Tetrodontophora bielanensis*, new record, morphological abnormalities, zoogeography, Bulgaria.

Introduction

The Collembola include 8857 described species worldwide (Bellinger et al. 1996-2018: http://www.collembola.org/doc/species.htm). According to Tsonev & Kazandzhieva (1991), 208 of these were recorded from Bulgaria until the 1990s. The same number was mentioned in Hubenov (1996, 2005, 2008). Forty-seven further species were recorded later as a result of the efforts of Thibaud (1995), Rusek (1997), Pomorski (1998), Pomorski & Skarżyński (1997a,b, 1998, 1999, 2000) and Smolis et al. (2004), thus rising the number of Bulgarian springtails to 255. However, according to different authors, the number of species in the Bulgarian list varies considerably. Hubenov (1991), for example, listed 190 springtail species from Bulgaria, Thibaud (1995) – 165, Deharveng (2007, cited after Sevgili & Özata 2014) mentioned 175, Fiera (2008) – 199 species, while Fiera (2016) and Fiera et al. (2017) listed 206 species. Comparing the state of knowledge on the Bulgarian collembolan fauna with that of other European countries [Spain: 706 species, France: 652, Ukraine: 496, Poland: 462, Italy: 420, Romania: 419, Slovakia: 415, Hungary: 412, Czech Republic: 355, Serbia and Montenegro: 273, Moldova: 251, Slovenia: 124, Greece (mainland): 105 (after Fiera 2016, Fiera et al. 2017)], it becomes clear that the species list of the currently known springtails from Bulgaria is far from complete (see also Pomorski & Skarżyński 1999).

In 2016 and 2017, while carrying out faunistic studies on the invertebrate fauna of the Kraishte Region (West Bulgaria), one of the faunistically most poorly known regions of Bulgaria (Hubenov 2008: p. 4), an interesting and new representative of the Bulgarian collembolan fauna was discovered – *Tetrodontophora bielanensis* (Waga, 1842) (Onychiuridae Lubbock, 1867).

Materials and Methods

The material of Collembola was collected by the author on the SE slopes of the Ruy Mountain (with highest peak Ruy, 1705.6 m a.s.l.), in the area of Lomnitsa Village (Trun Municipality, Pernik Region), alongside the road to Ruy Hut (42°52'22.7"N 22°37'26.8"E; 760-775 m a.s.l.). The collembolans were hand-collected on the right bank of the Lomnitsa (Lomnishka) River (Fig. 1) under leaf litter, stones, tile pieces and rotten wood in the ecotone of a beech forest with single hornbeam, willow, hazel trees and few dogwood bushes. Altogether 45 specimens (20♂♂, 15♀♀, 10 juv.) of *Tetrodontophora bielanensis* were collected: 7 (3♂♂, 3♀♀, 1 juv.) were collected on 12 March

Fig. 1. Habitat (a) and microhabitat (b) where *Tetrodontophora bielanensis* (Waga, 1842) was observed. Photographs by P. Mitov (12. III.2016).

2016, 34 (17♂♂, 12♀♀, 5 juv.) were collected on 29 April 2017, while the remaining 4 juvenile specimens were found on 4 July 2017. All the animals were kept alive, measured and photographed *in vivo*. To determine the sex of the collected springtails and to measure them easily, the animals were immobilised by placing them into a cellophane bag with a moistened soft sponge cloth. Photographs of living *T. bielanensis* were made with an Olympus EPL 3 camera fitted with a 60 mm macro-objective. The abnormal specimens were photographed under a Leica MS5 stereomicroscope equipped with a Leica DFC 295 digital camera. Digital images captured at different focal planes were assembled using Leica Application Suite (LAS, version 4.1.0) and edited in Adobe Photoshop. All measurements were made under a MBS-9 binocular microscope equipped with an ocular-micrometer. The springtails were identified after Gisin (1960); as an additional aid, the information in Bellinger et al. (1996-2018: http://www.collembola.org/taxa/tetrinae.htm#0113) was used. Forty-three specimens are currently kept in alcohol in the personal collection of the author. One male and one female specimens of *T. bielanensis* are deposited in the collection of the Faculty of Biology at the University of Sofia (BFUS), accession number BFUSPM000002 and BFUSPM000003.

The following symbols and abbreviations are used: CV = coefficient of variation; juv. = juvenile(s); L = body length; L$\bar{x}$ = average body length; N = number of individuals; W = body width; W$\bar{x}$= average body width; ± = Standard error of the mean; $\bar{x}$ = mean; SD = Standard deviation.

Results

The newly recorded from Bulgaria springtail species, *Tetrodontophora bielanensis* (Waga, 1842), increases the number of the local collembolan fauna to 256. This find appears quite surprising as *T. bielanensis* is one of the largest European springtail (Träser 1999,

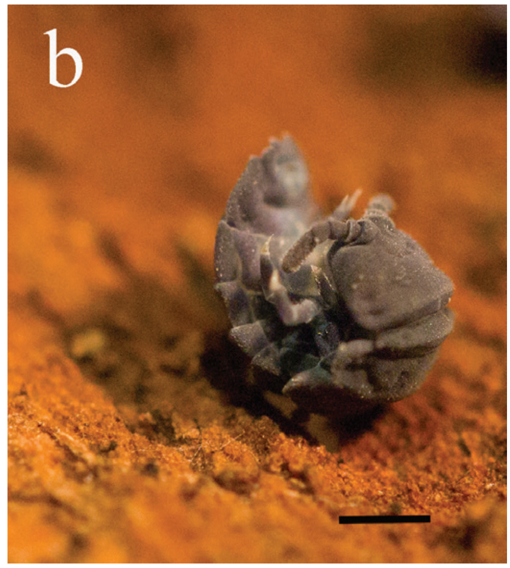

Fig. 2. *Tetrodontophora bielanensis* (Waga, 1842), specimens from Bulgaria: a. undisturbed, b. in a protective position. Photographs by Velislav Zarev (29.III.2016). Scale bar 1 mm.

Kontschán et al. 2003, Klausnitzer et al. 2005), reaching up to 9.2 mm in length [its width reaches 2.4 mm and its weight – 7.2 mg (Klausnitzer et al. 2005)]. The Bulgarian adult specimens (Fig. 2) were somewhat smaller: $L\bar{x}$=5.395±0.05mm (4.85-5.85 mm, SD=0.28, CV=0.051, N=30), $W\bar{x}$=2.258±0.02 mm (2.0-2.45 mm, SD=0.12, CV=0.052, N=30); males reached a length of 4.85-5.6 mm ($\bar{x}$ = 5.294±0.06, SD=0.24, CV=0.05, N=17) and a width of 2.0-2.35 mm ($\bar{x}$ = 2.21±0.03, SD=0.106, CV=0.05, N=17); females – 5.1-5.85 mm ($L\bar{x}$=5.53±0.07, SD=0.27, CV=0.05, N=13) and 2.1-2.45 mm ($W\bar{x}$=2.32±0.03, SD=0.1, CV=0.04, N=13), respectively, while the collected juveniles reached a length of 3.65-5.55 mm ($L\bar{x}$=4.39±0.24, SD=0.72, CV=0.16, N=9) and a width of 1.5-2.2 mm ($W\bar{x}$=1.81±0.08, SD=0.25, CV=0.14, N=9).

Morphological abnormalities

Three of the collected 45 *T. bielanensis* specimens (6.7%) showed some morphological anomalies (Fig. 3). The first one had an abnormal periproct, which was asymmetrical, perhaps due to regeneration following a mechanical trauma (Fig. 3a). In the second specimen (Fig. 3b), a tendency towards reduction of the anal spines and anal papillae was observed; a possible cause could be either manifested asymmetry or ecomorphosis (Najt & Massoud 1976, Hopkin 1997). The third specimen had an anomalous furcula (Fig. 3c) with completely absent dens and mucro, while the jumping organ was represented only by a part of the manubrium, most probably a result of a mechanical trauma during the early stages of development or a genetic anomaly (see also Konopova & Akam 2014). These cases represent the first described morphological abnormalities in *T. bielanensis* (cf. Najt & Massoud 1976, Najt & Dalens 1979, Hopkin 1997, and references therein).

Discussion

Chorological and zoogeographical notes

Tetrodontophora bielanensis has been previously recorded from Germany, Poland, the Czech Republic, Slovakia, Ukraine, Italy, Austria, Hungary, Romania, Moldova, Slovenia, Croatia, Bosnia, Serbia and Albania (Kontschán et al. 2003, Buşmachiu 2010). The species has been recently found also in Iran (Shayanmehr et al. 2013). This species lives also in caves of Ukraine, Poland, Slovakia and Romania (Vargovich 1997, Pomorski 1992, Kováč et al. 2016, Fiera et al. 2018).

The locality of its recent discovery in Bulgaria is about 1-4 km off the border with Serbia. Therefore, the presence of this springtail species in SE Serbia is quite possible as is its occurrence in the moist mountainous forest habitats of the Republic of Macedonia.

The main distribution zone of *T. bielanensis* includes the Sudeten and the Carpathians (Hauser 1970, Kontschán et al. 2003, Klausnitzer et al. 2005, Mahunka et al. 2013) and it has been classified as a *circumpannonian* species (Sterzyńska 1982, Träser 1999, Kontschán et al. 2003, Mahunka et al. 2013). Based on its distribution, habitat preferences (i.e., mountainous forest habitats between 900 and 1780 m a.s.l.) and because it is a psychro- and hygrophilous species (Hauser 1970, Bulimar 1987, Eisenbeis & Wichard 1987, Träser 1999, Smolis & Skarżyński 2006, Dányi & Traser 2008a), *T. bielanensis* has been also characterised as a *mountain-submontane* species (Stach 1929, Sterzyńska

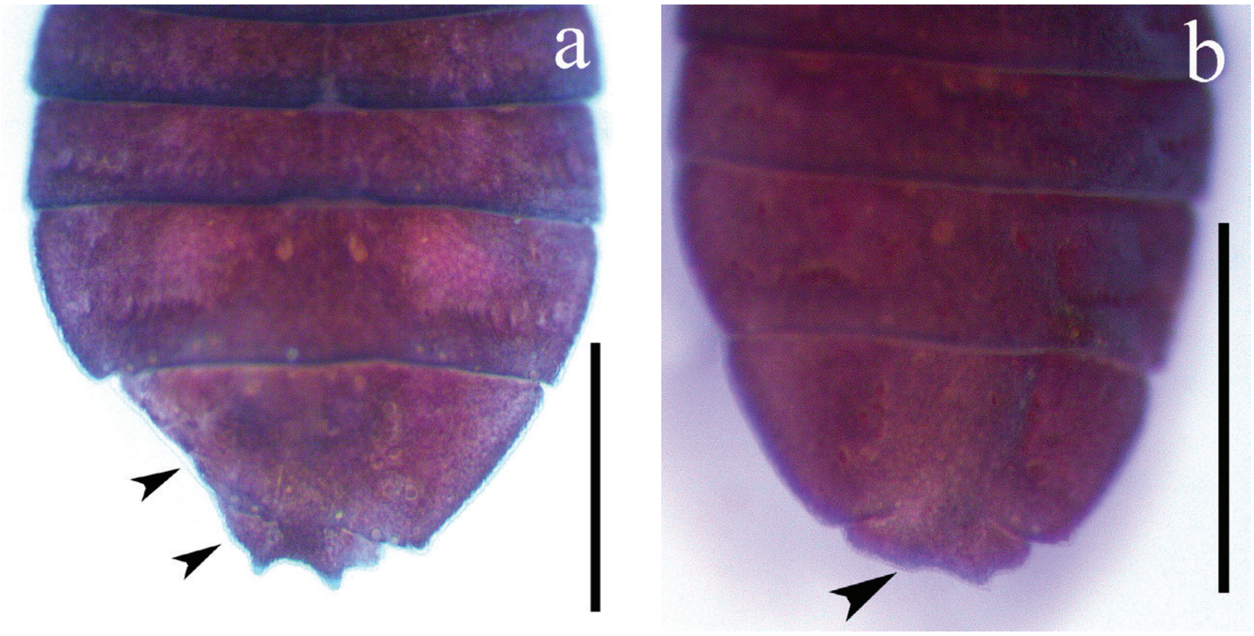

Fig. 3. *Tetrodontophora bielanensis* (Waga, 1842) (preserved in ethanol), specimens exhibiting abnormalities: a. male specimen with an anomalous, asymmetrical periproct (arrows); b. juvenile specimen with an asymmetrical anal segment: underdeveloped anal papilla, with a reduced anal spine (arrow); c. female with a partially reduced manubrium (arrow) and completely lacking dens and mucro of the jumping organ. Photographs by P. Mitov (12.VI.2017). Scale bar = 1 mm.

1982, Träser 1999, Smolis & Skarżyński 2006, Dányi & Traser 2008b, Buşmachiu 2010). Owing to all the above-mentioned chorological and ecological features, *T. bielanensis* can be placed in the group of the Central European mountainous faunistic element of the European faunistic complex in accordance with the typology proposed by Gruev (in Gruev & Kuzmanov 1994, 1999) for the zoogeographical complexes and elements of the Bulgarian fauna (see also Gruev 2002). The origin of this species can be traced within the Carpathians, or partly within the Alps, mainly because both had a major role as glacial refugia, later (post- and interglacially) becoming a secondary centre of dispersion towards the Balkans (see de Lattin 1949, 1967). The isolated occurrence of the species throughout South Europe and the Balkan Peninsula could be explained by its past southward migrations driven by the cooling during the Late Tertiary and the Quaternary glaciations as well as by its migrations back (recolonisation) from the Balkan refugium during the interglacial climate warmings (see also Gruev & Kuzmanov 1994 and Mahunka et al. 2013). Such processes could have shaped the present disjunctive mountainous areal of the species. Probably palaeogeographic (and faunistic) links of the Carpathian and Stara Planina Mts. during the Miocene-Pliocene (Georgiev 1990) might have been important for the distribution of this species in Western Bulgaria where, thanks to suitable conditions (moisture and cool forest habitats), it has survived. The observed longitudinal Euro-Asian disjunction in the occurrence of the giant springtail is most probably caused by the glaciations. The presence of the species in

North Iran (Gilan: Rasht) (Shayanmehr et al. 2013) could be an indication of a wider ancient distribution that is characteristic for some Central-European species (see Gruev & Kuzmanov 1994: p. 388) that have later become more restricted during the Quaternary glaciations. An alternative explanation could be a recent introduction but this seems highly speculative at this point.

Feeding notes

Tetrodontophora bielanensis is a detritivore species feeding on detrital materials originating from all trophic levels of the food web, i.e. plant and animal tissues, bacteria, algae and fungi. On the basis of stable isotope analysis (Fiera 2014) it has been assigned to the group of primary decomposers. In laboratory conditions, *T. bielanensis* feeds on a wide spectrum of fungi during the year according to their availability in the soil; however, it does not feed on bacteria, actinomycetes and other groups of soil microorganisms (Matic & Koledin 1985).

Conservational status

Tetrodontophora bielanensis is a Carpathian subendemic (Pawłowski 2009) and can be considered as being a rare and declining invertebrate species. It is listed in the Red Data Book of Ukraine (Akimov 2009) as „*Threatened with extinction*" and in the Red Book of the Ukrainian Carpathians (Mateleshko & Potish 2011), where it is evaluated as being of „*Least concern* (LC)". In Bulgaria, the giant springtail should also be subject to corresponding conservation measures.

Acknowledgements: I would like to thank Dr. Dariusz Skarżyński (Institute of Environmental Biology, University of Wrocław, Wrocław, Poland) and Dr. László Dányi (Hungarian Natural History Museum, Department of Zoology, Budapest, Hungary) for providing valuable information and literature; Dr. Eberhard Zielke (Germany) for sending literature; Dr. Velislav Zarev (IBER-BAS, Sofia) for photographing the springtails and for accompanying me during the field trips; MSc Ivailo Stoyanov (Sofia) for reading the manuscript. I am also grateful to three reviewers – two anonymous and Dr. Cristina Fiera (Institute of Biology Bucharest, Department of Ecology, Taxonomy and Nature Conservation, Bucharest, Romania), for their helpful comments.

References

Akimov I. A. (Ed.). 2009. Red Book of Ukraine. Wildlife. Kiev: Global Consulting Press. 624 p. (In Ukrainian).

Bellinger P. F., Christiansen K. A. & Janssens F. 1996-2018. Checklist of the Collembola of the World. http://www.collembola.org – Last updated on 31.07.2018. (Accessed 09.09.2018).

Bulimar F. 1987. Cercetări asupra comunităţilor de colembole edafice (Insecta: Collembola) la limita superioară a pădurii din Masivul Călimani. Anuarul Muzeului Judeţean Suceava, Fascicola Ştiinţele Naturii 9: 115–128.

Buşmachiu G. 2010. Checklist of Collembola from the Republic of Moldova. Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 53 (1): 149–160.

Dányi L. & Traser G. 2008a. Contribution to the Collembola fauna of Maramureş, Romania. Studia Universitatis "Vasile Goldiş", Seria Ştiinţele Vieii (Life Sciences Series), 18, suppl.: 211-219.

Dányi L. & Traser G. 2008b. An annotated checklist of the springtail fauna of Hungary (Hexapoda: Collembola). Opuscula Zoologica (Budapest), (2007) 38: 3–82.

Fiera C. 2008. New records of springtails (Hexapoda: Collembola) for Romanian fauna. Entomologica Romanica 13: 19–22.

Fiera C. 2014. Application of stable isotopes and lipid analysis to understand trophic interactions in springtails. North Western Journal of Zoology 10 (2): 227–235.

Fiera C. 2016. Occurrences and taxonomic status of Collembola in Europe. DOI: 10.6084/m9.figshare.3882159 (https://figshare.com/s/eb104db5b31cc22bb005)

Fiera C., Habel J. C., Kunz M. & Ulrich W. 2017. Large scale phylogenetic structure of European springtails (Collembola) depends on species range sizes and postglacial colonisation history. Biological Journal of the Linnean Society 120 (3): 664–674.

Fiera C., Habel J. C. & Ulrich W. 2018. Neutral colonisations drive high beta-diversity in cavernicole springtails (Collembola). PLoS ONE 13 (1): e0189638. https://doi.org/10.1371/journal.pone.0189638

Eisenbeis G. & Wichard W. 1987. Atlas on the Biology of Soil Arthropods. Berlin, Heidelberg: Springer-Verlag. 437 p.

Georgiev V. B. 1990. A zoogeographical sketch of Vitoša. In: Botev B., Golemanski V., Beshovski V. & Georgiev V. (Eds): Fauna of Southwestern Bulgaria. Part **3**. Sofia: Publishing house Bulgarian Academy of Sciences, pp. 238–242. (In Bulgarian, with Russian and English Summary).

Gisin H. 1960. Collembolenfauna Europas. Geneve: Museum d'Histoire Naturelle. 312 p.

Gruev B. 2002. About the Central European mountainous faunistic element in Bulgaria. Historia naturalis bulgarica 14: 17–27.

Gruev B. & Kuzmanov B.1994. General biogeography. Sofia: University Press "St. Kliment Ohridski". 498 p. (In Bulgarian).

Gruev B. & Kuzmanov B.1999. General biogeography. Plovdiv: Plovdiv University Press. 344 p. (In Bulgarian).

Hauser B. 1970. Zur Verbreitung des Riesencollembolen *Tetrodontophora bielanensis* (Waga, 1842) (Ins., Collembola, Onychiuridae). Berichte des Naturwissenschaftlich-medizinischen Vereins in Innsbruck 58: 297–304.

Hopkin S. P. 1997. Biology of the Springtails (Insecta: Collembola). Oxford: Oxford University Press. 330 p.

Hubenov Z. 1991. The Insect World of Bulgaria. In: Tsankov G. (Ed.): First National Conference on Entomology, 28-30 October 1991, Sofia (Reports and Communications, Section 'Systematics and General Entomology'). Sofia: Union of the Scientists in Bulgaria, Bulgarian Society of Natural Research, pp. 23–27 (In Bulgarian).

Hubenov Z. 1996. Faunistic diversity of Bulgaria – Invertebrates. Historia naturalis bulgarica 6: 11–16.

Hubenov Z. 2005. Entomofaunistic diversity of Bulgaria. In: Petrova A. (Ed.): Current state of Bulgarian biodiversity – problems and perspectives. Sofia: Bulgarian Bioplatform, Dragon, pp. 173–198. (In Bulgarian, English abstract).

Hubenov Z. 2008. Recent Fauna of Bulgaria – Animalia: Invertebrata. Acta zoologica bulgarica 60 (1): 3–21.

Klausnitzer B., Dunger W., Leutsch H., Sieber M. & Vogel J. 2005. Montan lebende Insekten im Zittauer Gebirge (Collembola, Lepidoptera, Coleoptera). Berichte Naturforschende Gesellschaft Oberlausitz 13: 83–89.

Konopova B. & Akam M. 2014. The Hox genes Ultrabithorax and abdominal-A specify three different types of abdominal appendage in the springtail *Orchesella cincta* (Collembola). EvoDevo 5 (1): 2.

Kontschán J., Murányi D.& Traser G. 2003. Data to the distribution of the *Tetrodontophora bielanensis* (Waga, 1842) (Collembola: Onyhiuridae). Annales historico-naturales Musei nationalis hungarici 95: 107–111.

Kováč L., Parimuchová A. & Miklisová D. 2016. Distributional patterns of cave Collembola (Hexapoda) in association with habitat conditions, geography and subterranean refugia in the Western Carpathians. Biological Journal of the Linnean Society 119: 571–592.

Lattin G. de 1949. Beiträge zur Zoogeographie des Mittelmeergebietes. Verhandlungen der deutschen Zoologischen Gesellschaft, Kiel, Jahrg. 1948: 143–151.

Lattin G. de 1967. Grundriss der Zoogeographie. Jena: VEB Gustav Fischer Verlag. 602 p.

Mahunka S., Murányi D. & Kontschán J. 2013. The role of the Balkan Peninsula in the origin and genesis of the soil fauna of the Carpathian Basin: history, aims and results. Opuscula Zoologica 44, Supplementum 1: 5–10.

Mateleshko O. Y. & Potish L. A. 2011. Red Book of Ukrainian Carpathians. Wildlife. Uzhorod: Karpaty. 366 p. (In Ukrainian).

Matic R., Koledin D. 1985. Preference and feeding specificity of *Tetrodontophora bielanensis* (Collembola, Insecta) under laboratory conditions. Revue d´Ecologie et de Biologie du Sol 22 (1): 121–129.

Najt J. & Massoud Z. 1976. Déformations morphologiques et étude des cas tératologiques chez les Collemboles. Revue d'Ecologie et de Biologie du Sol 13 (1): 205–218.

Najt J. & Dalens H. 1979. Anomalies morphologiques relevées chez des insectes Collemboles. Bulletin de la Société d'Histoire naturelle de Toulouse 115 (1-2): 172–180.

Pawłowski J. 2009. Endemic Invertebrates of the Carpathians. Roczniki Bieszczadzkie 17: 89–128.

Pomorski R. J. 1992. Collembola of caves and some adits of the Polish Sudetes. Acta Universitatis Wratislaviensis 25: 27–44.

Pomorski R. J. 1998. New Onychiurinae from Bulgaria and Turkey (Collembola: Onychiuridae). Polskie Pismo Entomologiczne 67: 3–11.

Pomorski R. J. & Skarżyński D. 1997a. A new species of *Pongeiella* from Bulgaria (Collembola: Onychiuridae: Tullbergiinae). Genus 8: 497–501.

Pomorski R. J. & Skarżyński D. 1997b. A new species of *Scaphophorura* from Bulgaria (Collembola: Onychiuridae). Polskie Pismo Entomologiczne 66: 3–7.

Pomorski R. J. & Skarżyński D. 1998. *Doutnacia ammophila* sp. n., with remarks on the genus *Doutnacia* Rusek, 1974 (Collembola: Onychiuridae: Tullbergiinae). Genus 9 (3): 247–252.

Pomorski R.J. & Skarżyński D. 1999. Springtails (Insecta, Collembola) collected on the Southern Black Sea Coast and Strandzha (Bulgaria). Acta zoologica bulgarica 51: 27–34.

Pomorski R. J. & Skarżyński D. 2000. A new species of *Endonura* Cassagnau, 1979 from Bulgaria with remarks on *Endonura centaurea* (Cassagnau & Peja, 1979) (Collembola, Neanuridae). Zoosystema 22 (1): 117–120.

Rusek J. 1997. *Jesenikia filiformis* gen. n., sp. n. (Collembola: Isotomidae) from Czech Republic and Bulgaria. European Journal of Entomology 94 (1): 115–120.

Sevgili H. & Özata M. A. 2014. Checklist of the springtails (Hexapoda: Collembola) of Turkey. Zoology in the Middle East 60 (2): 162–168.

Smolis A., Skarżyński D. & Pomorski R. J. 2004. A new species of the genus *Latriopyga* Caroli, 1910 (Collembola: Neanuridae: Neanurinae) from Bulgaria. Polskie Pismo Entomologiczne 73 (2): 155–160.

Smolis A. & Skarżyński D. 2006. Springtails (Collembola) of the „Barnowiec" reserve in the Beskid Sądecki Mountains (Polish Carpathians). Proceedings of the State Natural History Museum, Lviv 22: 69–77.

Shayanmehr M., Yahyapour E., Kahrarian M. & Lafooraki E. Y. 2013. An introduction to Iranian Collembola (Hexapoda): an update to the species list. ZooKeys 335: 69–83.

Stach J. 1929. Verzeichnis der Apterygogenea Ungarns. Annales historico-naturales Musei nationalis hungarici 26: 269–312. (1928).

Sterzyńska M. 1982. Springtails (Collembola) of Warsaw and Mazovia. In: Czechowski W., Garbarczyk H., Pisarski B. & Sawoniewicz J. (Eds): Species composition and origin of the fauna of Warsaw, 3. Memorabilia Zoologica 36: 217–234.

Thibaud J.-M. 1995: Collemboles de Bulgarie. I. Historia naturalis bulgarica 5: 19–27.

Träser G. 1999. Springtails of the Aggtelek National Park (Hexapoda: Collembola). In: Mahunka S. (Ed.): The fauna of the Aggtelek National Park. Budapest: Akadémiai Kiadó, pp. 49–59.

Tsonev I. K. & Kazandzhieva R. V. 1991. New Collembole species (Insecta, Collembola) for the Bulgarian fauna. Acta zoologica bulgarica 41: 80–84. (In Bulgarian, with Russian and English Summary).

Vargovich R. 1997. New Data on Collembola of Ukrainian Caves. Proceedings of the 12th International Congress of Speleology, Switzerland 6: 94–95.

Received: 10.11.2017
Accepted: 25.02.2018