Acta Soc. Zool. Bohem. **80**: 1–99, 2016
ISSN 1211-376X

Proceedings of the 16th International Congress of Myriapodology

Olomouc, Czech Republic
20–25 July 2014

Volume Editors

Karel Tajovský, Ivan Hadrián Tuf & Marcela Skuhravá

Workshop Participants

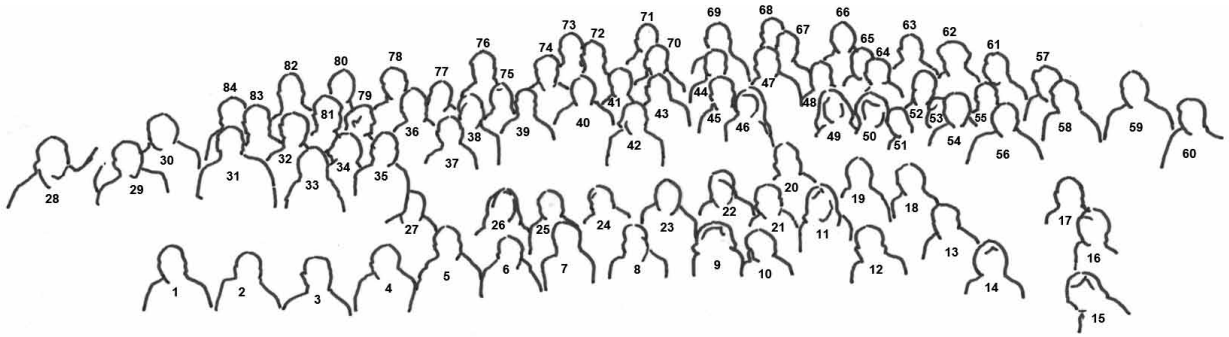


Fig. 1. Participants at the workshop. 1 – Boyan Vagalinski, 2 – Oliver Macek, 3 – Lucio Bonato, 4 – Hsueh-Wen Chang, 5 – Norman Lindner, 6 – Laura Del Latte, 7 – Irina Semenyuk, 8 – Michaela Bodner, 9 – Fieng-Lan Sun, 10 – Chao-chun Chen, 11 – Piyatida Pimvichai, 12 – Warut Siriwut, 13 – Natdanai Likhitrakarn, 14 – Małgorzata Leśniewska, 15 – Jolanta Wytwer, 16 – Michaela Kratochvílová, 17 – Christian Kronmüller, 18 – Cuong Huynh, 19 – Nattarin Wongthamwanich, 20 – João Paulo Pena-Barbosa, 21 – Julian Bueno-Villegas, 22 – Varpu Vahtera, 23 – Peter Decker, 24 – Barbara Jäschke, 25 – Julia Nefedieva, 26 – Roghaieh Zarei, 27 – Leszek Jendrysik, 28 – Ivan Hadrián Tuf, 29 – Karel Tajovský, 30 – Sergei Ilyich Golovatch, 31 – Günther Raspotnig, 32 – Hans S. Reip, 33 – Darina Bachvarova, 34 – Elena Valentinovna Mikhaljova, 35 – Michalina Kszuk-Jendrysik, 36 – Pavel Stoev, 37 – Somsak Panha, 38 – Nesrine Akkari, 39 – Pavel Nefediev, 40 – Jean-Jacques Geoffroy, 41 – Giuseppe Fusco, 42 – Karin Voigtländer, 43 – Jean-Francois David, 44 – Bjarne Meidell, 45 – Amazonas Chagas-Jr., 46 – Manoela Karam Gemael, 47 – Carsten H. G. Müller, 48 – Ivan Kos, 49 – Blanka Ravnjak, 50 – Maja Kastelic, 51 – Branka Vode, 52 – Megan Short, 53 – Hilke Ruhberg, 54 – Pavel Kocourek, 55 – Timotej Mock, 56 – Grzegorz Antoni Kania, 57 – John Gordon Elkan Lewis, 58 – Gregory D. Edgecombe, 59 – Joseph Hannibal, 60 – Vladimír Šustr, 61 – Michal Rendoš, 62 – Andrej Mock, 63 – László Dányi, 64 – Ansgar Poloczek, 65 – Stylianos Michail Simaiakis, 66 – Andy Sombke, 67 – Eivind Andreas Baste Undheim, 68 – Pavel Saska, 69 – Aleksandr Evsiukov, 70 – Willi Xylander, 71 – Bruce A. Snyder, 72 – Jan Philip Oeyen, 73 – Petr Dolejš, 74 – Henrik Enghoff, 75 – Ana Komerički, 76 – Markus Koch, 77 – Jörg Rosenberg, 78 – Iurii Diachkov, 79 – Daniela Bartel, 80 – Nikolaus Urban Szucsich, 81 – Zoltán Korsós, 82 – Thomas Wesener, 83 – Dávid Bogyó, 84 – Per Djursvoll.

Aleksandar Doichinov, Elisavet Georgopoulou, Eszter Lazányi, Gabriella Papastefanou and Irina Zenkova participated, but did not attend for the workshop photograph.

Logo of the 16ICM: Eva Tajovská

Reviewers: Ivan Kos, David Král, Bojan Mitic, Ahn Nguyen, Aline Quadros, Günther Raspotnig, Ulf Schelller, Arkady Schileyko, Marcela Skuhravá, Pavel Stoev, Karel Tajovský, Ivan Hadrián Tuf, Jolanta Wytwer

Language editor: Anthony F. G. Dixon

Acta Soc. Zool. Bohem. **80**: 5, 2016
ISSN 1211-376X

16th International Congress of Myriapodology, Olomouc, Czech Republic, 20–25 July 2014

Ivan Hadrián Tuf[1)] & Karel Tajovský[2*)]

[1)] Department of Ecology and Environmental Sciences, Faculty of Science, Palacký University, Šlechtitelů 27, CZ–779 00 Olomouc, Czech Republic
[2)] Biology Centre CAS, Institute of Soil Biology, Na Sádkách 7, CZ–370 05 České Budějovice, Czech Republic
*corresponding author: tajov@upb.cas.cz

The papers in this issue of *Acta Societatis Zoologicae Bohemicae* were presented at the 16th International Congress of Myriapodology (16ICM) held at Olomouc in the Czech Republic on 20–25 July 2014. International Congresses of Myriapodology are meetings of scientists, students and enthusiastic amateurs with specific interest in millipedes, centipedes, symphylans, pauropods and velvet worms. These meetings are organized under the auspices of the Centre International de Myriapodologie (http://www.myriapodology.org). To date, these congresses have been held in 13 countries over a period 46 years:

1ICM: 1968 – Paris, France;
2ICM: 1972 – Manchester, UK;
3ICM: 1975 – Hamburg, Germany;
4ICM: 1978 – Gargnano, Italy;
5ICM: 1981 – Radford, USA;
6ICM: 1984 – Amsterdam, The Netherlands;
7ICM: 1987 – Vittorio Veneto, Italy;
8ICM: 1990 – Innsbruck, Austria;
9ICM: 1993 – Paris, France;
10ICM: 1996 – Copenhagen, Denmark;
11ICM: 1999 – Bialowieza, Poland;
12ICM: 2002 – Mtunzini, South Africa;
13ICM: 2005 – Bergen, Norway;
14ICM: 2008 – Görlitz, Germany;
15ICM: 2011 – Brisbane, Australia;
16ICM: 2014 – Olomouc, Czech Republic.

16ICM was the first myriapodological congress to be held in the Czech Republic. The 84 participants and 18 accompanying persons came from 24 countries on five continents, making the 16th Congress a truly international and global meeting of myriapod specialists.

The organisers of the 16ICM are very grateful to Palacký University, Olomouc, which provided a pleasant area for all scientific as well as social parts of the Congress. We also thank the Biology Centre CAS and private support provided by several unnamed colleagues, which enabled several young students to participate in this Congress.

Many thanks to the Czech Zoological Society and Editorial board of the *Acta Societatis Zoologicae Bohemicae* for making a second set of the 16ICM papers freely available to a global online audience.

Acta Soc. Zool. Bohem. **80**: 7–16, 2016
ISSN 1211-376X

The millipede genus *Strongylosoma* in the Caucasus (Diplopoda: Polydesmida, Paradoxosomatidae)

Aleksandr Evsyukov[1)], Sergei Golovatch[2)] & Hans S. Reip[3)]

[1)] Lyceum No. 1 "Classical", Balakireva Str. 32, Rostov-on-Don 344004, Russia;
e-mail: aevsukov@mail.ru
[2)] Institute for Problems of Ecology and Evolution, Russian Academy of Science, Leninsky pr. 33,
Moscow 119071, Russia; e-mail: sgolovatch@yandex.ru
[3)] Senckenberg Museum of Natural History Görlitz, Am Museum 1,
D–02826 Görlitz, Germany; e-mail: reip@myriapoden-info.de
Corresponding author: sgolovatch@yandex.ru

Received 19 August 2014; *accepted 6 January 2015*
Published 12 April 2016

Abstract. Only two species of *Strongylosoma* Brandt, 1833 inhabit the Caucasus: *Strongylosoma kordylamythrum* Attems, 1898 and *S. lenkoranum* Attems, 1898. Both are quite distinct morphologically, their main diagnostic features are in the structure of the gonopod telopodite and shape of the ventral hump on male femur 3. The former species occurs in most of the Caucasus except for the region's eastern parts where only the latter species occurs. Parapatry is recorded only in Mountainous Karabakh and Hyrcania (within both southeastern Azerbaijan and northwestern Iran), but even there these species are strictly allopatric, in never being found together. Their distributions are refined and mapped, based both on records in the literature and an abundance of new samples.

Key words. Distribution, map, diagnostic features, Diplopoda, *Strongylosoma kordylamythrum*, *Strongylosoma lenkoranum*, Caucasus.

INTRODUCTION

The rather large, eastern Euro-Mediterranean millipede genus *Strongylosoma* Brandt, 1833 contains 13 unquestioned species or subspecies, which are confined to Central, Eastern and Southeastern Europe, the Caucasus and the Middle East. A further 30 species, largely tropical, are dubious (Nguyen & Sierwald 2013). For a long time only two species have been recorded as occurring in the Caucasus: *Strongylosoma kordylamythrum* Attems, 1898 and *S. lenkoranum* Attems, 1898 (e.g. Attems 1898, Lohmander 1936), but their distributions have hitherto remained rather obscure. The ubiquitous, definitely introduced *Oxidus gracilis* (C. L. Koch, 1847) is the only other member of the family Paradoxosomatidae recorded in the Caucasus (e.g. Lignau 1915).

The present paper is based on numerous new faunistic records, and summarizes and updates the nomenclatural history and distributions of both *Strongylosoma* species in the Caucasus.

MATERIAL AND METHODS

A large quantity of material of both *S. kordylamythrum* and *S. lenkoranum* was amassed by the second author, which is now mostly housed in the Zoological Museum of Moscow State University (ZMUM), Moscow, Russia. Additional samples were accumulated by the first and third authors, which are now in their private collections in Rostov-on-Don and Jena, referred to below as (AE) and (CHR), respectively. A further few samples are in the Staatliches Museum für Naturkunde, Görlitz (SMNG) and one in the Natural History Museum of Denmark, Copenhagen (ZMUC). This material allows not only serious refinements of the distributions of both these species, but also a clearer morphological diagnosis of both these species.

The following abbreviations are used: D – description or descriptive notes, R – new records, M – mere mention, ind. – individual, juv. – juvenile form.

TAXONOMIC PART

Strongylosoma kordylamythrum Attems, 1898
(Figs 1, 2, 5)

Strongylosoma kordylamythrum Attems, 1898: 312 (D).
Strongylosoma kordylamythrum: Lignau 1903: 32 (D, R), 1915: 376 (D, R); Attems 1914: 227 (M), 1926: 247 (D), 1937: 38, 39 (D); Verhoeff 1921: 40, 42 (D, R), 1940: 37 (D); Lohmander 1936: 32 (D, R); Lang 1959: 1795 (R), 1964: 241 (R); Kobakhidze 1965: 391 (R); Jeekel 1968: 94 (M); Ljovuschkin & Lokshina, 1975: 211 (R); Golovatch 1983: 167 (R); Talikadze 1984: 143 (M); Bababekova 1996: 90 (R), Enghoff & Moravvej 2005: 68 (R); Golovatch & Matyukhin 2011: 115 (R); Evsyukov & Golovatch 2013: 209 (D, R); Nguyen & Sierwald 2013: 1268 (M); Zuev 2014: 348 (R).
Strongylosoma cordylamythrum (lapsus calami!): Muralewicz 1907: 340 (M, R), 1911: 10 (M), 1913: 220 (R); Ghilarov 1972: 38 (R).
Strongylosoma pallipes (misidentification): Muralewicz 1927: 7 (M).
Strongylosoma lenkoranum (misidentification): Lohmander 1932: 3 (M).

Material examined. **Russia**: 2 ♂♂, 1 ♀ (ZMUM ρ2480). **Chechenia**: Argun River valley, 5 km N of Shatoi, *Corylus*, *Fagus*, *Carpinus* etc. forest, 750 m a. s. l., litter, under stones & bark, 18 July 1986; 2 ♂♂, 1 ♀ (ZMUM ρ2481). **Ingushetia**: Barsuki near Nazran, *Crataegus* & *Fraxinus* grove along road, litter & under stones, 6 June 1982; 1 ♀ (ZMUM ρ2482), Assa River valley, ca. 9 km SSW of Muzhichi, 800 m a. s. l., *Fagus*, *Alnus*, *Carpinus* etc. forest, litter, under bark & stones, 15 July 1986, all leg. S. Golovatch; 1 ♂ (AE). **Dagestan**: Makhachkala, park, 1 December 2012, leg. Galimova; 1 ♀ (AE), Makhachkala, 14 April 2012; 1 ♀ (AE), Khindakh, 11 June 2012, all leg. E. Il'yna; 1 ♂, 1 ♀ (ZMUM ρ2483). **Krasnodar Prov**.: Sochi, Khosta, *Taxus* & *Buxus* grove with *Fagus*, litter & under bark, 15 May 1985; 1 ♀ (ZMUM ρ2484), Caucasian Nature Reserve, Pslukh, 20 km E of Krasnaya Polyana, Mt Kogot, *Fagus* & *Abies* forest, 1400 m a. s. l., litter, under bark & stones, 18–20 May 1985; 3 ♂♂ (ZMUM ρ2485), Caucasian Nature Reserve, Krasnaya Polyana, 600–750 m a. s. l., *Quercus*, *Fagus*, *Castanea*, *Caprinus* etc. forest, litter, bark, stones, 8–9 August 1986; 1 ♂, 1 ♀, (ZMUM ρ2486), Sochi, Khosta, *Taxus* & *Buxus* grove, litter, 28 October 1981; 4 ♀♀ (ZMUM ρ2487), Tuapse Distr., 15 km SE of Novomikhaylovskiy, Psebe, deciduous forest, under stones, litter & in rotten logs, 29 October 1981; 1 ♀, 1 juv. (ZMUM ρ2488), same locality, Mt Fatse, 28 August 1974, all leg. S. Golovatch; 5 ♀♀ (ZMUM ρ2489), near Psebe, cave, 11 July 1961, leg. S. Ljovuschkin; 1 ♂, 2 ♀♀, 1 juv. (ZMUM ρ2490□), Sochi, ca. 8 km E of Khosta, Cave "Our Lady", 16 May 1985; 2 ♀♀ (ZMUM ρ2491), same locality, *Buxus*, *Fagus*, *Acer* etc. forest, litter, under stones, 18 May 1985; 3 ♂♂, 2 ♀♀ (ZMUM ρ2492), Severskaya Distr., 2–10 km S of Ubinskaya, *Quercus*, *Fagus*, *Carpinus* etc. forest, 300–450 m a. s. l., litter & under bark, 3 & 4 July 1986, all leg. S. Golovatch; 1 ♀, 1 juv. (ZMUM ρ2493), near Khosta, Cave Labirintovaya, 27 November 1985, leg. N. Myuge; 1 ♂ (ZMUM ρ2494), Krasnaya Polyana, 6–8 April 1978, leg. V. Dolin; 10 ♂♂, 4 ♀♀ (ZMUM ρ2495). **Adygea**: Caucasian Nature Reserve, Pasture Abago near Guzeripl, *Abies*, *Fagus*, *Acer*, *Betula* etc. forest, up to timber line & in subalpine meadow, 1700–1850 m a. s. l., litter, under bark & stones, 24–26 May 1985; 1 ♂, 1 ♀ (ZMUM ρ2496), same locality, *Abies* & *Fagus* forest, 1350–1400 m a. s. l., litter, under bark & stones, 24–26 May 1985, all leg. S. Golovatch; 1 ♀ (AE), near Kamennomostskiy, Meshokho River valley, under stones, 26 June 2011, leg. D. Khisametdinova; 1 ♀ (AE), same locality, litter, 17 June 2007, leg. A. Evsyukov; 1 ♀ (AE), near Nikel, Belaya River valley, 28 June 2007, leg. G. Chesnokov; 1 ♂ (AE), same locality, 18 June 2010; 1 ♀ (AE), same locality, under logs, 28 August 2009, all leg. A. Evsyukov; 1 ♂ (AE), same locality, 18 June 2010, leg. I. Gorbenko; 2 ♂♂, 2 ♀♀ (AE), Caucasian Nature Reserve, Lagonaki (= Lago-Naki) Plateau, 24 June 2010, leg. A. Evsyukov & D. Khisametdinova; 1 ♀ (AE), Maikop, 14 March 2008, leg. M. Nartbiev; 2 ♀♀ (AE), near Kamennomostskiy, 16 June 2012, leg. M. Shapovalov; 1 ♂ (AE), Azish-Tau Mt Ridge, forest, under stones, 10 May 2013, leg. Y. Kochetov & D. Khisametdinova; 1 ♂, 1 ♀ (CHR), Lagonaki (= Lago-Naki) Plateau, source area of Kurdships River, 44º 04' 45.1" N, 40º 00' 00" E, 16 August 2012; 1 ♀ (CHR), Urushten River valley, right bank, 1 km upstream of bridge at Kordon Chernorechye, *Acer & Fagus* forest with *Sambucus*, *Corylus*, *Alnus*, *Ulmus* in understorey, 43.9319º N, 40.6778º E, 850 m a. s. l., 18 August 2012; 1 ♀ (CHR), Lagonakskiy Mountain Ridge, limestone cliffs on SW slope of Mt Matuk, 44.1061º N, 39.9225º E, 1810 m a. s. l., 16 August 2012; 2 ♀♀ (CHR), Mount Oshten, S of Lake Psheno-Dagh, limestone block field, 44.0092º N, 39.9008º E, 1970 m a. s. l., 25 August 2012, all leg. F. Walther; 1 ♂, 1 ♀ (SMNG), Mt Koryto, 44.067º N, 40.352º E, 1800 m a. s. l., August–September 1999, leg. O. Tietz; 4 ♂♂ (SMNG), Sakhray River, camp, 44º05'56" N, 40º23'56.4" E, 26 May 2004; 7 ♂♂, 6 ♀♀, 2 juv. (SMNG), W slope of Mt Asbestnaya, 44º 00' 28.8" N, 40º 27' 32.4" E, 26 August 2005; 1 ♀ (SMNG), W of Afonka Valley, 44º 00' 07.2" N, 40º 24' 21.6" E, 27 August 2005, all leg. K. Voigtländer; 5 ♂♂, 1 ♀, 3 juv. (ZMUM ρ2497). **Stavropol Prov**.: Zheleznovodsk, 10 July 1974; 4 juv. (ZMUM ρ2498), same locality, 29 June.1974; 2 ♂♂, 1 ♀, 6 juv. (ZMUM ρ2499), Zheleznovodsk, 15 July 1974; 2 ♂♂, 1 ♀, 1 juv. (ZMUM

ρ2500□□), same locality, foot of Mt Zheleznaya, deciduous forest, litter & under stones, 30 May 1982; 1 ♂ (ZMUM ρ2501), W of Zheleznovodsk, *Quercus* & *Crataegus* scrub, litter, 29 May 1982; 4 ♀♀, 1 ♂, 1 juv. (ZMUM ρ2502), 3 km E of Zheleznovodsk, forest of *Carpinus*, *Acer* etc., litter & under stones, 30 May 1982; 2 ♀♀ (ZMUM ρ2503), 3 km E of Zheleznovodsk, *Carpinus*, *Acer*, *Fraxinus* forest, litter & under stones, 30 May 1982; 4 ♂♂, 3 ♀♀ (ZMUM ρ2504), Pyatigorsk, Mt Mashuk, 600 m a. s. l., park of *Fraxinus*, *Acer*, *Quercus* etc., litter. 29 May 1982; 1 ♂, 3 ♀♀, 1 juv. (ZMUM ρ2505), E of Georgievsk, forest of *Quercus*, *Fagus*, *Acer*, litter & under bark, 7 June 1985; 1 ♂ (ZMUM ρ2506), same locality, 28 & 31 May 1982, all leg. S. Golovatch; 1 ♀ (ZMUM ρ2507), same locality, park in a sanatorium, litter, under stones, on walls, 1 June 982; 1 ♂, 1 ♀ (ZMUM ρ2508), Stavropol, Russkiy Forest, 09 March 2014, leg. & det. R. Zuev; 1 ♂ (CHR), same locality, Russian Forest near Komsomolskiy Water Reservoir, deciduous forest (*Quercus*, *Carpinus*, *Acer*), camp, 45º 04' 81" N, 41º 95' 67" E, 530 m a. s. l., 22 August 2012, leg. F. Walther; 1 juv. (ZMUM ρ2509). **Karachaevo-Cherkessia**: Urup Distr., 3 km E of Pregradnaya, 800 m a. s. l., *Quercus*, *Fagus*, *Alnus*, *Corylus* etc. forest, litter & rotten wood, 3 August 1986; 2 ♂♂, 2 ♀♀, 7 juv. (ZMUM ρ2510), Lower Teberda S of Karachaevsk, 1000 m a. s. l., *Quercus*, *Fagus* etc. forest, litter, 3 August 1986; 1 ♂, 1 ♀ (ZMUM ρ2511), Teberda Nature Reserve, Mt Malaya Khatipara above Teberda Town, 29–30 May 1985; 1 ♀ (ZMUM ρ2512), Teberda Nature Reserve, Kizgich Canyon N of Arkhyz, wet riverine *Alnus & Betula* forest, 1450–1500 m a. s. l., litter, under bark & stones, 5 June 1985; 1 ♂ (ZMUM ρ2513), same locality, *Abies*, *Picea*, *Pinus*, *Fagus*, *Betula* & *Acer* forest, 1550–1650 m a. s. l., litter, under bark & stones, 5 June.1985; 1 ♀, 1 juv. (ZMUM ρ2514), Pass Gumbashi ca. 32 km NE of Karachaevsk, 2000 m a. s. l., subalpine meadow, under stones, 11 July 1986; 2 ♂♂ (ZMUM ρ2515), ca. 30 km S of Kurjinovo, Bolshaya Laba River valley, 4 km N of Damkhurts, 1050–1100 m a. s. l., *Fagus*, *Acer*, *Picea* etc. forest, litter & bark, 4 August.1986; 1 ♂, 1 ♀ (ZMUM ρ2516), Teberda Nature Reserve, Canyon Gonachkhir between Teberda & Dombai, road to Klukhor Pass, 1700–1900 m a. s. l., *Abies*, *Fagus*, *Acer* etc. forest, 1 June 1985; 2 juv. (ZMUM ρ2517), Teberda Nature Reserve, Mt Mussa-Achitara

Fig. 1. *Strongylosoma kordylamythrum* Attems, 1898, female from Adygea, habitus. A – dorsal view, B – lateral view. Photographed by A. Tikhonov, taken not to scale.

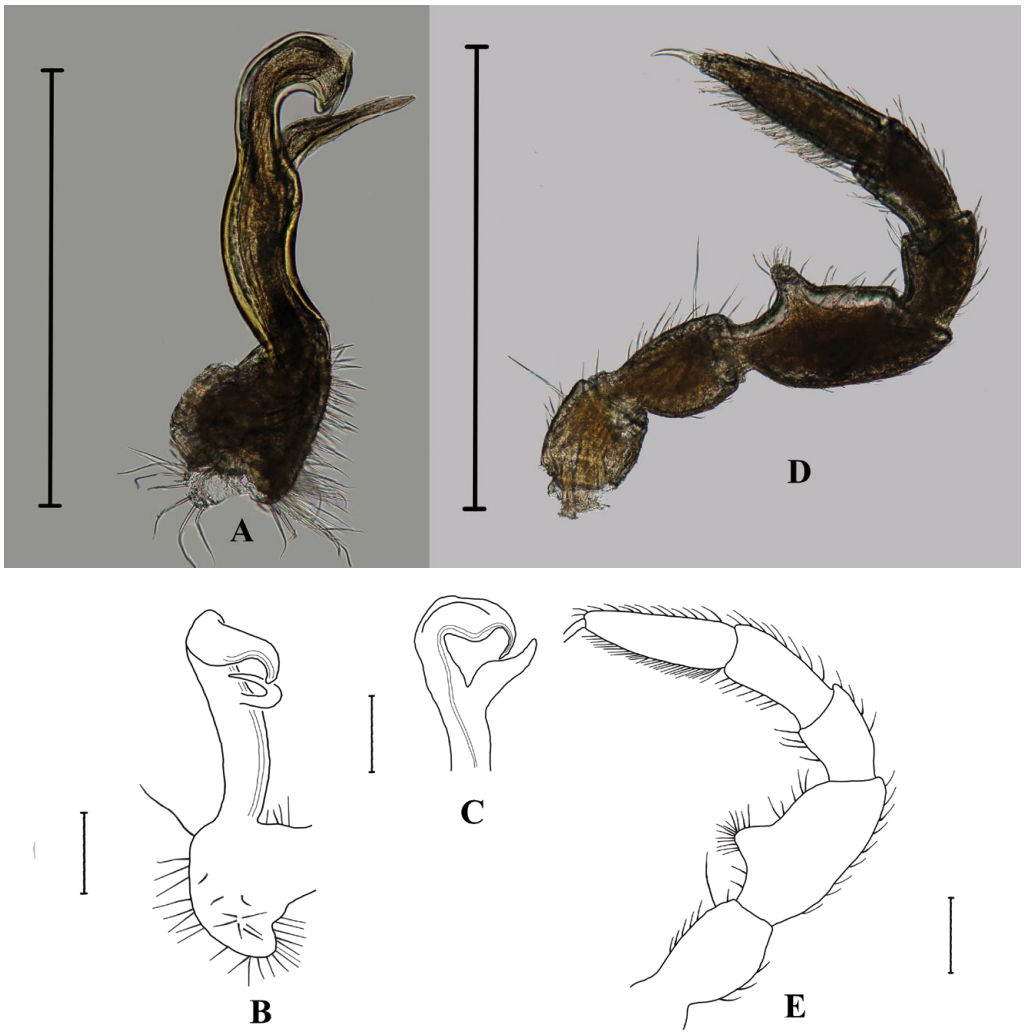


Fig. 2. *Strongylosoma kordylamythrum* Attems, 1898, male from Adygea. A – left gonopod, lateral view. B – left gonopod, lateral view. C – end part of left gonopod, ventral view. D and E – leg of the third pair. Photographed by V. Schmatko, scale bars: 2.0 mm. Del. A. Evsyukov, scale bars: 0.5 mm.

near Dombai, 2700–2800 m a. s. l., alpine meadow, under stones, 29 July 1986; 2 ♂♂, 5 ♀♀ (ZMUM ρ2518), Teberda Nature Reserve, Dombai, *Abies*, *Fagus*, *Picea*, *Betula*, *Acer* etc. forest, 1700–1800 m a. s. l., litter, under bark & stones, 31 May 1985, all leg. S. Golovatch; 1 ♀ (AE), Teberda Nature Reserve, Mt Malaya Khatipara, 24 July 2012, leg. D. Khisametdinova & Y. Kochetov; 1 ♂ (SMNG), "Kaukasus, Dombai, Cuchur-Tal, 2 June 1984, leg. W. Dunger"; 1 ♂ (ZMUC), 2–3 km NE of Dombai, SW slopes of Musat-Cheri Mt. Range, 43º 17'44" N, 41º 38' 24.7" E, 2000 m a. s. l., *Abies*-*Fagus*-*Picea* forest, sifting leaf litter 25 July 2011, leg. A. Solodovnikov; 2 ♂♂, 1 ♀, 1 juv. (ZMUM ρ2519). **Kabardino-Balkaria**: Baxan River valley, Bedyk between Tyrnyauz & Zhankhoteko, 900 m a. s. l., *Corylus*, *Fagus* & *Carpinus* scrub, litter & under stones, 20 July 1986; 1 ♂, 1 ♀, 5 juv. (ZMUM ρ2520), Lower Chegem, 800 m a. s. l.,

Fagus forest, litter, 14 July 1986; 1 ♂, 1 juv. (ZMUM ρ2521), Chegem Distr., 5 km S of Upper Chegem, 1700 m a. s. l., *Betula*, *Pinus* & *Juniperus* forest, litter, 12 July.1986; 6 ♂♂, 8 ♀♀, 2 juv. (ZMUM ρ2522), Chegem Distr., Upper Chegem, meadow, under stones, 1500 m a. s. l., 12 July 1986, all leg. S. Golovatch. 1 ♂, 6 ♀♀, 3 juv. (ZMUM ρ2523). **North Ossetia**: near Novo-Georgievskoye by Mozdok, *Quercus*, *Acer*, *Ulnus*, *Fraxinus* etc. forest, litter & under stones, under bark of logs, 27 May 1982; 1 ♀, 1 juv. (ZMUM ρ2524), S of Ordjonikidze (now Vladikavkaz), between Chmi & Baltik, *Quercus & Ulmus* forest on slope, litter & under stones, 2 June 1982, all leg. S. Golovatch; 1 ♂ (AE), Tanandon River valley, 2000 m a. s. l., forest, litter, 9 August 2010, leg. A. Evsyukov & D. Khisametdinova. **Abkhazia**: 1 ♂ (ZMUM ρ2525), environs of Sukhumi, Shromy, 30 April 1970; 1 ♂ (ZMUM ρ2526), same locality, 27 April 1970; 1 ♂, 1 ♀ (ZMUM□ ρ2527), "sample No. 8", under bark, 29 April 1971, all leg. N. Zalesskaya; 1 ♀ (ZMUM ρ2528), Sukhumi, 200 m a. s. l. SE of Besletsky Bridge, Cave Ammonalnaya I, 13 November 1987, leg. N. Myuge; 2 ♂♂, 2 ♀♀ (ZMUM ρ2529), Sukhumi, Botanical Garden, 9 October 1978; 1 ♂, 1 ♀ (ZMUM ρ2530), same locality, litter, 20 October 1978; 1 ♀ (ZMUM ρ2531), SE of Lake Ritsa, between Pass Anchkho & Pskhu, 1300–1450 m a. s. l., *Fagus*, *Acer* etc. forest on slope, under bark & stones, 14 & 16 August 1986; 1 ♂, 5 ♀♀ (ZMUM ρ2532), Myussera Nature Reserve, 20–130 m a. s. l., mixed deciduous forest (*Castanea*, *Alnus* etc.), litter, under bark & stones, 8–10 April 1983; 1 ♀ (ZMUM ρ2533), near Lake Ritsa, forest, litter, 24 October 1978; 2 ♂♂ (ZMUM ρ2534), Sukhumi Distr., Bzyb River valley, Pskhu, 700–950 m a. s. l., *Fagus*, *Quercus*, *Castanea* etc. forest, litter, under bark & stones, 15–16 August 1986; 6 ♂♂, 6 ♀♀ (ZMUM ρ2535), environs of Sukhumi, near Cave Kelassuri, litter, 11 April 1983; 1 ♂, 1 ♀ (ZMUM ρ2536), Lake Ritsa, 950–1100 m a. s. l., *Fagus*, *Abies*, *Picea*, *Acer* etc. forest, litter, under bark and stones. 13–14 August 1986, all leg. S. Golovatch; 6 ♂♂ (ZMUM ρ2537), Sukhumi Distr., Lower Yashtukha, 29 March 1985, leg. A. Markossian; 1 ♀ (ZMUM ρ2538), Tsandripsh, 15 August 2011, leg. E. Khatchikov. **Georgia**: 1 ♀ (ZMUM ρ2539), Ambrolauri Distr., near Nikortsminda, 1100 m a. s. l., near Cave Sakinule, 10 July 1974; 1 ♀ (ZMUM ρ2540), 40 km W of Mestia, Kherkhvashi E of Nakra, 1250–1700 m a. s. l., *Quercus*, *Fagus*, *Carpinus*, *Picea*, *Abies* etc. forest, litter & bark, 21 August – 21 September 1986; 1 ♀ (ZMUM ρ2541), Borzhomi Distr., 8 km SE of Akhaldaba, 1000 m a. s. l., Nedzura River valley, *Picea*, *Carpinus* & *Fagus* forest, litter, logs, 12 May 1983, all leg. S. Golovatch; 2 ♀♀ (CHR), Samegrelo-Zemo Svaneti, Nodashi, 43º 03'31.0" N, 42º 24' 59.0" E, 1100 m a. s. l., 29 September 2012, leg. F. Walther; 5 ♀♀ (CHR), Sairme Gorge, mixed forest, leaf litter (*Acer* & *Betula*), 41º 50' 48.5" N, 42º 48' 27.0" E, 2200 m a. s. l., 11 July 2013; 1 ♀ (CHR), Ambrolauri to Djava, E of Oni, NE of Pipileti, 42º 34' 04.4" N, 43º 29' 58.2 E, mixed forest, 1 July 2014, all leg. L. Mumladze. **Azerbaijan**: 1 ♂ (ZMUM ρ2542), ca 20 km E of Alazani River, September 1981, leg. S. Alekseev; 1 ♂ (ZMUM ρ2543), Mountainous Karabakh, ca. 15 km WSW of Mardakert, 1100 m a. s. l., *Quercus*, *Fagus*, *Acer* etc. forest, litter, 2 June 1987; 1 ♀ (ZMUM ρ2544), Mountainous Karabakh, Turshsu ca. 15 km S of Shusha, 1700 m a. s. l., *Quercus*, *Carpinus*, *Acer* etc. forest, litter. 3 June 1987, all leg. S. Golovatch & K. Eskov.

Remarks. This species is very common and widespread throughout much of the Caucasus, also occurring in the adjacent Rostov-on-Don Prov. and Kalmykia (Evsyukov & Golovatch 2013). In the northern Caucasus (Stavropol Province), *S. kordylamythrum* has been found in bird nests (Golovatch & Matyukhin 2011), thus suggesting occasional ornithochory. The specimens in northernmost samples, both from the Rostov-on-Don Prov. and Kalmykia, tend to be considerably smaller than those from the Caucasus proper (Evsyukov & Golovatch 2013). Apparently, this reflects the less favourable conditions this species experiences at the northern periphery of its distribution. Obviously the same concerns the southernmost population that occurs in a city park in Tehran, Iran (Enghoff & Moravvej 2005).

Swarming was occasionally observed (Zheleznovodsk and Pyatigorsk, summer 1974, SG) (Golovatch & Matyukhin 2011).

Strongylosoma lenkoranum Attems, 1898
(Figs 3–5)

Strongylosoma lenkoranum Attems, 1898: 67: 314 (D).

Strongylosoma lenkoranum: Attems 1914: 227 (M), 1926: 247 (D), 1937: 38 (D); Verhoeff 1921: 42 (D), 1940: 37 (D); Lohmander 1936: 40 (D, R); Kobakhidze 1965: 391 (R); Jeekel 1968: 94 (M); Hoffman & Lohmander 1968: 84 (R); Samedov et al. 1972: 1245 (R); Rakhmanov 1972: 116 (R); Golovatch 1983: 169 (R), 1995: 127 (R); Enghoff & Moravvej 2005: 68 (R); Enghoff 2006: 190 (R); Nguyen & Sierwald 2013: 1268 (M).

Strongylosoma stragulatum Lohmander, 1932: 4 (D) – synonymized with *Strongylosoma lenkoranum* by Attems 1937: 38.

Strongylosoma leukoranum [lapsus calami!]: Lang 1964: 240 (R).

Strongylosoma lencoranum [lapsus calami!]: Bababekova 1996: 90 (R).

Fig. 3. *Strongylosoma lenkoranum* Attems, 1898 male from Azerbaijan, habitus. Same as in Fig. 1.

Material examined. **Armenia**: 4 ♂♂, 2 ♀♀ (ZMUM ρ2545), Kafan Distr., Shikahoh Nature Reserve, Shikahoh, 900–950 m a. s. l., *Quercus*, *Fagus*, *Carpinus* forest near spring, litter, logs, and under stones, 28 April 1983; 1 ♂, 1 ♀ (ZMUM ρ2546), Shikahoh Nature Reserve, Nerkin And, old *Platanus* stand along river, litter, in rotten wood, under stones, 600 m a. s. l., 30 April 1983; 2 ♂♂, 1 ♀ (ZMUM ρ2547), Megri Distr., above Kuris, 1500 m a. s. l., *Quercus* and *Acer* forest, litter, under bark & stones along springs, 26 April 1983; 3 ♂♂, 7 ♀♀ (ZMUM ρ2548), Yerevan, park, litter, 16 November 1985, all leg. S. Golovatch; 1 ♀ (ZMUM ρ2549), Stepanavan, 1600–1650 m a. s. l., *Quercus*, *Fagus*, *Carpinus* etc. forest, litter & under bark. 21–22 May 1987, leg. S. Golovatch & K. Eskov. **Azerbaijan**: 1 ♂, 1 ♀ (ZMUM ρ2550), ca. 5 km N of Kutkashen (now Gabala), 1150–1200 m a. s. l., *Fagus & Carpinus* forest, litter & rotten wood, 2 May 1987; 2 ♂♂ 1 ♀ (ZMUM ρ2551), Shemakha Distr., Pirkuli, near Observatorium, 1200–1250 m a. s. l., *Quercus*, *Acer*, *Taxus* etc. forest, litter, 30 April 1987, all leg. S. Golovatch & K. Eskov; 1 ♂ (ZMUM ρ2552), same locality, 24 May 1988, leg. N. Loginova; 1 ♂, 5 ♀♀ (ZMUM ρ2553), SW of Kuba, 750 m a. s. l., *Fagus*, *Quercus*, *Caprinus* etc. forest, litter & under bark, 23 April 1987; 1 ♂, 2 ♀♀ (ZMUM ρ2554), ca. 12 km E of Ismailly, Girdyman-Chay River valley, 850–880 m a. s. l., *Fagus*, *Quercus*, *Carpinus*, *Acer* forest, litter & under bark, 1 May 1987; 2 ♂♂, 1 ♀, 5 juv. (ZMUM ρ2555), Mountainous Karabakh, Terter River valley, Nadirkhanly ca. 12 km NE of Kelbajar, 1200 m a. s. l., *Fraxinus* & *Juglans* stand,

litter, 1 June 1987, all leg. S. Golovatch & K. Eskov; 2 ♂♂, 1 ♀, 1 juv. (ZMUM ρ2556), Mountainous Karabakh, near Firyuza, Domy, 1650 m a. s. l., pine forest, 14 August 1977, leg. N. Zalesskaya; 4 ♂♂, 3 ♀♀ (ZMUM ρ2557), Masally Distr., Istisu ca. 8 km SW of Masally, *Quercus*, *Acer*, *Carpinus* etc. forest, 80–140 m a. s. l., litter, under bark & stones, 19–20 October 1983, leg. S. Golovatch.

Remarks. This species is even more widely distributed than *S. kordylamythrum*, being known from Georgia, Azerbaijan, Armenia, Iran, and Turkey. It has also been recorded in Afghanistan (Golovatch 1995), where it is likely to have been introduced. In the Caucasus, it appears generally to be distributed more southerly and easterly than *S. kordylamythrum*.

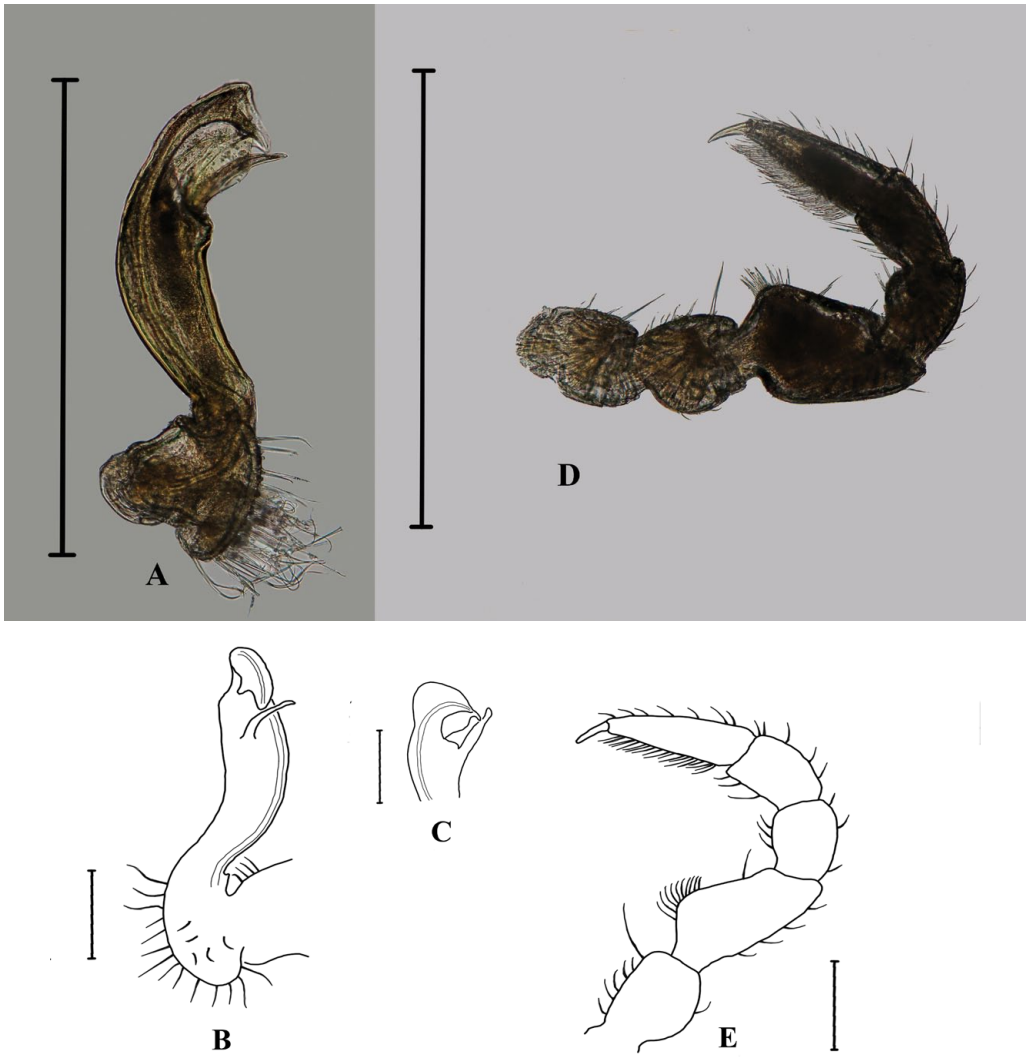


Fig. 4. *Strongylosoma lenkoranum* Attems, 1898 male from Azerbaijan. Same as in Fig. 2.

CONCLUSION

Superficially, *S. kordylamythrum* and *S. lenkoranum* are very similar. Attems (1898) described them, based only on minor details of the conformation of the gonopods. It is not surprising, therefore, that they were sometimes confused (Verhoeff 1921) or misidentified (Muralewicz 1927, Lohmander 1932), until Lohmander (1936) found and illustrated sufficiently reliable characters for discriminating these two species. The diagnostic characters are lying in the structure of the gonopods, mainly the shapes of the distofemoral process and solenomere, and that of the ventral hump on male femur 3 (cf. Fig. 1 D and E and Fig. 2 D and E).

Our map (Fig. 5) shows that the distributions of *S. kordylamythrum* and *S. lenkoranum* in the Caucasus region differ considerably. Nguyen & Sierwald (2013) listed only "Georgia, Caucasus, Iran" for the former and "Georgia, Caucasus" for the latter. In fact, *S. kordylamythrum* occurs throughout the northern Caucasus (Krasnodar and Stavropol provinces, Adygea, Karachaevo-Cherkessia, Kabardino-Balkaria, North Ossetia, Ingushetia, Chechenia and Dagestan), reaching

Fig. 5. Map showing the distributions of *Strongylosoma kordylamythrum* Attems, 1898 (asterisk) and *S. lenkoranum* Attems, 1898 (square).

both the Rostov-on-Don Region and Kalmykia in the north. In Transcaucasia, this species inhabits Abkhazia, Georgia and Azerbaijan, including Hyrcania both within southeastern Azerbaijan and northwestern Iran. In contrast, *S. lenkoranum* occurs only in Transcaucasia, including the eastern part of the Caucasus Major within Azerbaijan, most of the Caucasus Minor within Georgia (Kartli), Armenia and Azerbaijan (Mountainous Karabakh), and Hyrcania within both Azerbaijan and Iran. Moreover, this species is also known from northeastern Turkey and from Kabul, Afghanistan.

The distributions of these two species overlap only in two regions: Mountainous Karabakh and Hyrcania (Fig. 5). Both might seem to show parapatry, but in fact, based on the numerous new samples reported above, they are allopatric and never found together. The records of both species cited by Attems (1898) from near Lenkoran, Azerbaijan and by Lohmander (1932, 1936) on Mt Boghro-dagh, Iran, are not for syntopic, coexisting populations. Our Fig. 5 includes all known records of *S. kordylamythrum* and *S. lenkoranum* in the Caucasus and adjacent parts of Turkey and Iran.

As regards the patterns in the distributions of both *Strongylosoma* species in terms of altitude in the Caucasus, they are very similar in showing clear-cut preferences for either lowland or midmontane areas, mostly forest habitats below 2000 m a. s. l. Truly high-montane occurrences in (sub)alpine meadows are extremely rare. The same concerns troglophilic populations. It is this general similarity in habitat/ecological preferences that seems to account for their allopatry.

A c k n o w l e d g e m e n t s

We are most grateful to all colleagues who placed their material at our disposal. We are also greatly obliged to Vladimir Schmatko and Alexey Tikhonov, both of Rostov-on-Don, who skillfully took the pictures. Henrik Enghoff, ZMUC, kindly provided a reference to the only relevant sample in ZMUC.

REFERENCES

Attems C. 1898: System der Polydesmiden. I. Theil. *Denkschriften der Kaiserlichen Akademie der Wissenschaften zu Wien*, *Mathematisch-Naturwissenschaftliche Classe* **67**: 221–482.

Attems C. 1914: Die indo-australischen Myriopoden. *Archiv für Naturgeschichte* **80A** (4): 1–398.

Attems C. 1926: Etude sur les Myriopodes recueillis par M. Henri Gadeau de Kerville pendant son voyage zoologique en Syrie. *Voyage Zoologique d'Henri Gadeau de Kerville en Syrie* **1**: 221–266.

Attems C. 1937: Myriapoda 3. Polydesmoidea I. Fam. Strongylosomidae. *Das Tierreich* **68**: i–xxii, 1–300.

Bababekova L. A. 1996: Podtip trahejnye – Tracheata [The subphylum of tracheates – Tracheata]. Pp.: 89–97. In: Aliev S. V. & Kasymov E. G. (eds): *Životnyj mir Azerbajdžana. Tom 2. Tip členistonogie* [*Animal Life of Azerbaijan. Volume 2. The Phylum of Arthropods*]. Baku: Elm, 412 pp (in Russian).

Enghoff H. 2006: The millipedes of Turkey (Diplopoda). *Steenstrupia* **29**: 175–198.

Enghoff H. & Moravvej S. A. 2005: A review of the millipede fauna of Iran. *Zoology in the Middle East* **35**: 61–72.

Evsyukov A. P. & Golovatch S. I. 2013: Millipedes (Diplopoda) from the Rostov-on-Don Region, southern Russia. *Arthropoda Selecta* **22**: 207–215.

Ghilarov M.S. 1972: Počvennaâ fauna buroziomov Bolšogo Kavkazskogo hrebta [Soil fauna of brown soils of the Greater Caucasus Range]. Pp.: 37–38. In: Ghilarov M. S. (ed.): *Problemy počvennoj zoologii. Materialy četvertogo vsesoûznogo soveŝaniâ*, *Baku*, *1972* [*Problems in Soil Zoology*. *Materials of the 4th All-Union Conference*, *Baku*, *1972*]. Moskva: Nauka, 176 pp (in Russian).

Golovatch S. I. 1983: A contribution to the millipede fauna of Iran (Diplopoda). *Annalen des Naturhistorischen Museums in Wien* **85B**: 157–169.

Golovatch S. I. 1995: On several new or poorly-known Oriental Paradoxosomatidae (Diplopoda Polydesmida), II. *Arthropoda Selecta* **3**: 127–137.

Golovatch S. I. & Matyukhin A. V. 2011: New records of millipedes (Diplopoda), mainly from bird nests, in European Russia. *Arthropoda Selecta* **20**: 115–116.

Hoffman R. L. & Lohmander H. 1968: The Diplopoda of Turkey. *Mitteilungen des Hamburgischen Zoologischen Museums und Instituts* **65**: 61–121.

Jeekel C. A. W. 1968: On the classification and geographical distribution of the family Paradoxosomatidae (Diplopoda, Polydesmida). PhD Thesis. Rotterdam: Academisch Proefschrift, 168 pp (Privately Published).

Kobakhidze D. N. 1965: Spisok diplopod (Diplopoda) Gruzinskoj SSR [A list of the millipedes (Diplopoda) of the Georgian Soviet Republic]. *Fragmenta Faunistica* **11**: 390–398 (in Russian, with summaries in Polish and German).
Lang J. 1959: K poznaniû mnogonožek (Diplopoda) territorii SSSR [To the knowledge of millipedes (Diplopoda) of the territory of the USSR]. *Zoologičeskij Žurnal* **38**: 1790–1796 (in Russian, with a summary in English).
Lang J. 1964: Diplopoden aus Griechenland, Kreta, der Türkei und Iran aus dem Sammlungen von Dr. K. Lindberg. *Acta Societatis Zoologicae Bohemoslovacae* **28**: 237–246.
Lignau N. G. 1903: Mnogonožki Černomorskogo poberež'â Kavkaza. Die Myriopoden am Kaukasischen Schwarzmeerufer. *Mémoires de la Société des Naturalistes de la Nouvelle-Russie* **25**: 82–149 (in Russian and German).
Lignau N. G. 1915: Vielfüssler aus Abchasien. *Annuaire du Musée Zoologique de l'Académie Impériale des Sciences de Petrograd* **19**: 349–401.
Ljovuschkin S. I. & Lokshina I. E. 1975: K voprosu o svâzi peŝernyh diplopod s počvoj [To the question of the relationships of cave millipedes with the soil]. Pp.: 210–211. In: Eitminaviciute I. (ed.): *Problemy počvennoj zoologii. Materialy pâtogo vsesoûznogo soveŝaniâ*, *Vilnûs*, *1975* [*Problems in Soil Zoology*. *Materials of the 5th All-Union Conference*, *Vilnius*, *1975*]. Vilnius: Institute of Zoology and Parasitology, Academy of Sciences of the Lithuanian Soviet Republic, 365 pp (in Russian).
Lohmander H. 1932: Neue Diplopoden aus Persien. *Göteborgs Kungliga Vetenskaps- och Vitterhets-Samhälles Handlingar*, *Series 5B* **3**(2): 1–44.
Lohmander H. 1936: Über die Diplopoden des Kaukasusgebietes. *Göteborgs Kungliga Vetenskaps- och Vitterhets-Samhälles Handlingar*, *Series 5B* **5**(1): 1–196.
Muralewicz W. S. 1907: Zur Myriapodenfauna des Kaukasus. *Zoologischer Anzeiger* **31**: 329–351.
Muralewicz W. S. 1911: Očerk fauny Myriopoda Kavkaza [Essay on the fauna of Myriopoda of the Caucasus]. *Mitteilungen des Kaukasischen Museums* **5**: 1–80 (in Russian).
Muralewicz W. S. 1913: Členistonogiâ. – Arthropoda. Glava VIII. Klass mnogonožki. – Myriapoda [Arthropods. – Arthropoda. Chapter VIII. Class of Myriapods. – Myriapoda]. *Trudy Obŝestva Izučeniâ Černomorskogo Poberež'â*, *Sankt-Peterburg* **2**: 215–221 (in Russian).
Muralewicz W. S. 1927: K faune Myriopoda Kavkaza [To the fauna of Myriopoda of the Caucasus]. *Acta Societatis Entomologicae Stauropolitanae* **3**(1): 1–7 (in Russian).
Rakhmanov R. R. 1972: Dvuparnonogie mnogonožki Lenkoranskoj zony Azerbajdžana [Millipedes of the Lenkoran zone of Azerbaijan]. P.: 116. In: Ghilarov M. S. (ed.): *Problemy počvennoj zoologii. Materialy četvertogo vsesoûznogo soveŝaniâ*, *Baku*, *1972* [*Problems in Soil Zoology*. *Materials of the 4th All-Union Conference*, *Baku*, *1972*]. Moskva: Nauka, 176 pp (in Russian).
Samedov N. G., Bababekova L. A. & Rakhmanov R. R. 1972: Razmeŝenie mnogonožek (Myriopoda) v različnyh tipah počv Lenkorani [Distribution of myriapods (Myriopoda) in various soil types of Lenkoran']. *Zoologičeskij Žurnal* **51**: 1244–1247 (in Russian, with a summary in English).
Talikadze D. A. 1984: O faune dvuparnonogih mnogonožek (Diplopoda) Kolhidskoj provincii Kavkaza [On the millipede fauna (Diplopoda) of the Colchian Province of the Caucasus]. *Zoologičeskij Žurnal* **63**: 142–145 (in Russian, with a summary in English).
Nguyen A. D. & Sierwald P. 2013: A worldwide catalog of the family Paradoxosomatidae Daday, 1889 (Diplopoda: Polydesmida). *Check List* **9**: 1132–1353.
Verhoeff K. W. 1921: Chilognathen-Studien (91. Diplopoden-Aufsatz). *Archiv für Naturgeschichte* **86A**(12): 23–80.
Verhoeff K. W. 1940: Über Diplopoden aus der Türkei. Türkiyedeki diplopodlar hakkinda. *Revue de la Faculté de Sciences de l'Université d'Istanbul*, *Séria B*, **5**(1/2): 1–49 (in German, with a summary in Turkish).
Zuev R. V. 2014: Preliminary data on the millipedes (Diplopoda) from the Stavropol Territory, northern Caucasus, Russia. *Arthropoda Selecta* **23**: 347–354.

Acta Soc. Zool. Bohem. **80**: 17–20, 2016
ISSN 1211-376X

Defensive secretions in millipede species of the order Julida (Diplopoda)

Grzegorz KANIA[1)], Radosław KOWALSKI[2)] & Rafał PIETRAŚ[3)]

[1)] Department of Biology and Parasitology, Radziwiłłowska 11, Medical University, PL–20-080 Lublin, Poland; e-mail: grzegorzkania@umlub.pl
[2)] Department of Analysis and Evaluation of Food Quality, Skromna 8, University of Life Sciences, PL–20-704 Lublin, Poland
[3)] Department of Medicinal Chemistry, Jaczewskiego 4, Medical University, PL–20-090 Lublin, Poland

Received 3 December 2014; *accepted 25 February 2015*
Published 12 April 2016

Abstract. The defensive compounds in the secretions of four species of millipede of the order Julida, *Cylindroiulus caeruleocinctus* (Wood, 1864), *C. latestriatus* (Curtis, 1845), *Choneiulus palmatus* (Nemec, 1895) and *Ommatoiulus sabulosus* (Linnaeus, 1758), were characterized using GC/MS analyses. The secretions contain mixtures of nine compounds of benzoquinones. A characteristic mixture of benzoquinones in the defensive secretions of the order Julida consists of 2-methyl-1,4-benzoquinone, 2-methoxy-3-methyl-1,4-benzoquinone, 2,3-dimethoxy-1,4-benzoquinone and 2,3-dimethoxy-5-methyl-1,4-benzoquinone, together with trace amounts of 1,4-benzoquinone and hydroquinone.

Key words. Defensive secretion, benzoquinones, GC/MS analyses, Millipedes, Diplopoda, Julida.

INTRODUCTION

The defensive secretions of millipedes differ in their content, depending on the taxonomic group. Repugnatorial glands are present in millipedes, except those in the orders Siphoniulida, Sphaerotheriida and Chordeumatida. The production of cyanogenic compounds is a characteristic of the order Polydesmida (Taira et al. 2003, Makarov et al. 2010, Kuwahara et al. 2011). Alkaloids are produced by the orders Glomerida and Polyzoniida (Mori & Takagi 2000, Shear et al. 2011). Compounds such as p-cresol and phenol are secreted by the orders Callipodida (Ćurčić et al. 2009, Shear et al. 2010) and Julida (Vujisic et al. 2011, Bodner & Raspotnig 2012, Sekulić et al. 2014). Benzoquinones are secreted by the orders Spirobolida, Spirostreptida (Eisner et al. 1978, Deml & Huth 2000, Kuwahara et al. 2002, Arab et al. 2003, Wu et al. 2007) and Julida (Huth 2000, Vujisic et al. 2011, Bodner & Raspotnig 2012).

The objective of this study was the identification of chemicals secreted by the following species of millipedes of the order Julida: *Cylindroiulus caeruleocinctus* (Wood, 1864), *C. latestriatus* (Curtis, 1845), *Choneiulus palmatus* (Nemec, 1895) and *Ommatoiulus sabulosus* (Linnaeus, 1758). Despite the fact that the chemical secretions of the two common species, *O. sabulosus* and *C. caeruleocinctus,* have been previously analyzed by Huth (2000), we included both these species in the study because of their tendency to achieve outbreaks levels in urban areas.

MATERIALS AND METHODS

The millipedes *Cylindroiulus caeruleocinctus* and *Ommatoiulus sabulosus* were collected at Kraków and Lublin, Poland, in fallow areas, gardens and from walls of residential buildings and in the case of *Cylindroiulus latestriatus* and *Choneiulus palmatus* in greenhouses in the Botanical Garden of the University Maria Curie-Skłodowska at Lublin, Poland.

Chemical Extraction

For the collection of defensive secretions, ten specimens of each species of millipede were put into a glass vial (1.5 ml), to which 200 µl of dichloromethane (DCM) was then added after which the vial was sealed and then shaken for two minutes on a shaker (Vortex type). The extract was collected by decantation followed by a gas chromatography-mass spectrometry (GC-MS) analysis.

Chemical analyses and Identification

GC/MS: Gas chromatography GC 450 (Varian, USA) with mass spectrometry detector MS 320 (Varian, USA) equipped with a CP-810 autosampler and a 30 m × 0.25 mm VF-5 ms column (Varian, USA), film thickness 0.25 µm, carrier gas He 0.5 ml/min., injector and detector temperature were used, respectively, at 250 °C and 270 °C; split ratio 1:40; inject volume 2 µl. A temperature gradient was applied (40 °C for 3 minutes, then incremented by 6 °C /min to 270 °C, kept at 270 °C for 0.67 minute, then incremented by 20 °C /min to 290 °C): ionization energy 70 eV; mass range: 45–400 Da; scan time 0.80 s.

The qualitative analysis was carried out on the basis of MS spectra, which were compared with the spectra in the NIST library, and with data available in the literature on the compounds previously identified in the defensive secretions of millipedes (Arab et al. 2003, Deml & Huth 2000, Wu et al. 2007, Vujisić et al. 2011).

RESULTS

A total of nine benzoquinone derivatives were identified (Table 1) in the defensive secretions of the four species of the order Julida, viz. *C. caeruleocinctus*, *C. latestriatus, Ch. palmatus* and *O. sabulosus.* The chemical structures of these compounds are closely related. The two major constituents of the secretion are: 2-methyl-1,4-benzoquinone and 2-methoxy-3-methyl-1,4-benzoquinone. In the secretion produced by *O. sabulosus* the major constituent (34.28%) is 2-methyl-1,4-benzoquinone. The relative abundance of the major compound, 2-methoxy-3--methyl-1,4-benzoquinone, was significantly higher in *C. caeruleocinctus, C. palmatus,* and *O. sabulosus* than in *C. latestriatus* (44.47, 39.33, 53.79 vs. 0.31%). Furthermore, the relative content of 2-methyl-3,4-methylenedioxyphenol in the defensive exudates of *C. latestriatus* was significantly higher than in that of *C. caeruleocinctus*, *C. palmatus*, and *O. sabulosus* (50.16 *vs*. 9.69, 6.25, 1.52%). The other benzoquinones that are minor components in the defensive secretion of Julida are: 2,3-dimethoxy-1,4-benzoquinone and 2,3-dimethoxy-5-methyl-1,4-benzoquinone. Interestingly, we identified higher quantities of some minor compounds e.g. 2,3-dimethoxy-5-methyl-1,4-benzoquinone (comprising a total of 13.72% of chromatogram peak-area in the case of *C. caeruleocinctus*). Trace amounts of 1,4-benzoquinone and hydroquinone were also recorded.

DISCUSSION

The data reveal that the defensive chemicals produced by the millipede orders Spirobolida, Spirostreptida and Julida, first described as "quinone millipedes" by Eisner et al. (1978), are chemically similar. The most common compounds in the defensive secretions of the four julid millipede species studied are mainly 2-methyl-1,4-benzoquinone and 2-methoxy-3-methyl-1,4--benzoquinone, which is in agreement with previous data on Julida (Huth 2000, Vujisić et al. 2011, 2014, Bodner & Raspotnig 2012, Sekulić et al. 2014), Spirostreptida (Williams & Singh 1997, Deml & Huth 2000) and Spirobolida (Kuwahara et al. 2002, Arab et al. 2003, Wu et al. 2007). The major compound in the defensive secretion of *C. caeruleocinctus*, *C. palmatus* and *O. sabulosus* is 2-methoxy-3-methyl-1,4-benzoquinone. The compound 2-methyl-3,4-methylenedioxyphenol is recorded in the defensive secretion of Spirobolida (Wu et al. 2007) and julid millipede species (Vujisić et al. 2011, Sekulić et al. 2014) and confirmed by our analyses. The minor components 2,3-dimethoxy-1,4-benzoquinone and 2,3-dimethoxy-5-methyl-1,4-benzoquinone are recorded in the defensive secretion of *Acladocricus setigerus* (Silvestri, 1897) (Wu et al. 2007), the julid millipede species *Allajulus dicentrus* (Latzel, 1884) (Bodner & Raspotnig 2012) and *Unciger*

Table 1. Chemical compounds in the defensive secretions produced by four julid millipede species. Abbreviations: RI – retention index obtained from GC/MS data, nd – not detected

no	compound	RI	relative abundance (content in %)			
			Cylindroiulus caeruleocinctus CC	*Cylidroiulus latestriatus* CL	*Choneiulus palmatus* CP	*Ommatoiulus sabulosus* OS
1.	1,4-benzoquinone	9.146	nd	nd	0.08	0.65
2.	2-methyl-1,4- benzoquinone	11.870	12.16	29.66	28.99	34.28
3.	2-methoxy-3-methyl-1,4-benzoquinone	16.208	44.47	0.31	39.33	53.79
4.	hydroquinone	18.244	0.72	0.04	0.33	0.33
5.	2-methoxy-5-methyl-2,5-cyclohexadiene-1,4-dione	20.074	nd	nd	0.27	0.12
6.	2-methyl-3,4-(methylenedioxy)phenol	21.236	9.69	50.16	6.25	1.52
7.	2-methyl-1,4-benzenodiol	20.100	2.48	4.45	4.93	3.35
8.	2,3-dimethoxy-5-methyl-1,4-benzoquinone	21.760	13.72	2.51	3.49	0.43
9.	2,3-dimethoxy-1,4-benzoquinone	21.893	1.43	0.30	1.99	1.75

transsilvanicus (Verhoeff, 1899) (Sekulić et al. 2014), which is in accordance with the results of the present study.

We detected 1,4-benzoquinone and hydroquinone, which confirms results of previous studies on julid species (Huth 2000, Vujisić et. al. 2011, Bodner & Raspotnig 2012, Sekulić et al. 2014). We identified trace amounts of 1,4-benzoquinone in the defensive fluids of the stripped millipede *O. sabulosus,* which confirms previous data recorded for the stripped millipede (Huth 2000) and *Megaphyllum bosniense* (Verhoeff, 1897) (Vujisić et. al. 2011).

The benzoquinones in the defensive secretions of julid millipedes have antibacterial, antifungal and antihelminthic qualities (Williams & Singh 1997). Moreover, benzoquinones secreted by tropical species cause staining and burning of the skin and, in the case of eyes, causes lacrimation, keratitis and ulceration of the cornea (Haddad et al. 2000, Buden et al. 2004, De Capitani et al. 2011). Therefore, the benzoquinone secretions of *Cylindroiulus latestriatus, Choneiulus palmatus, C. caeruleocinctus* and *O. sabulosus,* which occur in urban areas, may be dangerous for humans.

REFERENCES

Arab A., Zacarin G. G., Fontanetti C. S., Camargo-Mathias M. I., Santos M. G. & Cabrera A. C. 2003: Composition of the defensive secretion of the Neotropical millipede Rhinocricus padbergi Verhoeff 1938 (Diplopoda: Spirobolida: Rhinocricidae). *Entomotropica* **18**: 79–82.

Bodner M. & Raspotnig G. 2012: Millipedes that smell like bugs: (E)-alkenals in the defensive secretion of the julid diplopod Allajulus dicentrus. *Journal of Chemical Ecology* **38**: 547–556.

Ćurčić B. M., Makarov S. E., Tešević V. V., Jadranin M. B. & Vujisić L. V. 2009: Identification of Secretory Compounds from the European Callipodidan Species Apfelbeckia insculpta. *Journal of Chemical Ecology* **35**: 893–895.

Buden D. W., Attygalle A. & Wu X. 2004: Distribution of the Chunk Islands Giant Millipede, Acladocricus setigerus (Spirobolida: Rhinocricidae), and identification of its defensive compounds. *Pacific Science* **58**: 625–636.

De Capitani E. M., Vieira R. J., Bucaretchi F., Fernandes L. C. R., Toledo A. S. & Camargo A. C. 2011: Human accidents involving Rhinocricus spp., a common millipede genus observed in urban areas of Brazil. *Clinical Toxicology* **49**: 187–190.

Deml R. & Huth A. 2000: Benzoquinones and hydroquinones in defensive secretions of tropical millipedes. *Naturwissenschaften* **87**: 80–82.

Eisner T., Alsop D., Hicks K. & Meinwald J. 1978: Defensive secretions of millipedes. Pp.: 41–72. In: Bettini S. (ed.): *Handbook of Experimental Pharmacology Arthropod Venoms*. *Vol. 48.* Berlin: Springer, 977 pp.

Haddad Jr. V. & Cardoso J. L. C. 2000: Accidents provoked by millipede with dermatological manifestations: report of two cases. *Anais Brasileiros de Dermatologia* **75**: 471–474.

Huth A. 2000: Defensive secretions of millipedes: more than just a product of melting point decrease? Pp.: 191–200. In: Wytwer J. & Golovatch S. I. (eds): *Progress in Studies on Myriapoda and Onychophora. Fragmenta Faunistica* **43**(Supplement): 1–395.

Kuwahara Y., Noguchi S., Mori N. & Higa Y. 2002: Identification of benzoquinones and hydroquinones as the secretory compounds from three species of Okinawan millipedes. *Japanese Journal of Environmental Entomology and Zoology* **13**: 117–124.

Kuwahara Y., Shimizu N. & Tanabe T. 2011: Release of hydrogen cyanide via a post-secretion Schotten-Baumann reaction in defensive fluids of Polydesmoid millipedes. *Journal of Chemical Ecology* **37**: 232–238.

Makarov S. E., Curcić B. P., Tesević V. V., Jadranin M. B., Vujisić Lj. V., Curcić S. B., Mandić B. M., Sekulić T. Lj, & Mitic B. M. 2010: Defensive secretions in three species of polydesmids (Diplopoda, Polydesmida, Polydesmidae). *Journal of Chemical Ecology* **36**: 978–982.

Mori K. & Takagi Y. 2000: Enantioselective synthesis of polyzonimine and nitropolyzonimine, spirocyclic compounds from the defensive glands of a millipede, Polyzonium rosalbum. *Tetrahedron Letters* **41**: 6623–6625.

Sekulić T. Lj., Vujisić Lj. V., Ćurčić B. P. M., Mandić B. M., Antić D. Ž., Trifunović S. S., Godevac D. M., Vajs E. V., Tomić V. T. & Makarov S. E. 2014: Quinones and non-quinones from the defensive secretion of Unciger transsilvanicus (Verhoeff, 1899) (Diplopoda, Julida, Julidae), from Serbia. *Archives of Biological Sciences* **66**: 385–390.

Shear W. A., McPherson I. S., Jones T. H., Loria S. F., & Zigler K. S. 2010: Chemical defense of a troglobiont millipede, Tetracion jonesi Hoffman (Diplopoda, Callipodida, Abacionidae). *International Journal of Myriapodology* **3**: 153–158.

Shear W. A, Jones T. H. & Wesener T. 2011: Glomerin and homoglomerin from the North American pill millipede Onomeris sinuata (Loomis, 1943) (Diplopoda, Pentazonia, Glomeridae). *International Journal of Myriapodology* **4**: 1–10.

Taira J., Nakamura K. & Higa Y. 2003: Identification of secretory compounds from the millipede, Oxidus gracilis C. L. Koch (Polydesmida: Paradoxosomatidae) and their variation in different habitats. *Applied Entomology and Zoology* **38**: 401–404.

Williams L. A. D. & Singh P. D. A. 1997: Biology and biological action of the defensive secretion from a Jamaican millipede. *Naturwissenschaften* **84**: 143–144.

Wu X., Buden D. W. & Attygale B. 2007: Hydroquinones from defensive secretion of a giant Pacific millipede, Acladocricus setigerus (Diplopoda: Spirobolida). *Chemoecology* **17**: 131–138.

Vujisić L. V., Makarov S. E., Ćurčić B. P. M., Ilić B. S., Tešević V. V., Godevac D. M., Vučković I. M., Ćurčić B. S. & Mitić B. M. 2011: Composition of the defensive secretion in three species of European millipedes. *Journal of Chemical Ecology* **37**: 1358–1364.

Acta Soc. Zool. Bohem. **80**: 21–31, 2016
ISSN 1211-376X

On the consistency of some taxonomic characters in the Scolopendromorpha and comments on the scolopocryptopid subfamily Kethopinae (Myriapoda: Chilopoda)

John G. E. Lewis

Manor Mill Farm, Halse, Taunton, Somerset TA4 3AQ, United Kingdom;
e-mail: johngelewis@realemail.co.uk

Received 28 November 2014; *accepted 29 January 2015*
Published 12 April 2016

Abstract. With the increase in taxonomic data it has become apparent that some characters are less reliable as phylogenetic and taxonomic characters in the Scolopendromorpha than previously thought. Examples of this are considered. The problematic scolopocryptopid subfamily Kethopinae is discussed. New World species of *Scolopendra* Linnaeus, 1758 plus the Old World species *S. valida* Lucas, 1840 are a monophyletic group, usually with an anterior transverse sulcus (ring furrow) on T1. A subgroup of ten species have 17 antennal articles, and dorsodistal prefemoral spines on legs anterior to the ultimate pair. A second subgroup of six species have more than 17 antennal articles and lack the dorsodistal prefemoral spines on legs anterior to the ultimate pair. Exceptions are discussed. *S. valida* fits into neither group. Some *Cryptops* (*Trigonocryptops*) Verhoeff, 1906 lack the otherwise characteristic sternite trigonal sutures and *C.* (*Cryptops*) *anomalans* Newport, 1844 shows some of the morphological characters used to characterise *Trigonocryptops* Verhoeff, 1906. The rather incomplete data for *Kethops utahensis* (Chamberlin, 1909) (Scolopocryptopidae, Kethopinae) and the description of *Thalkethops grallatrix* Crabill, 1960 suggests that they are characterised by ultimate legs with rows of saw teeth on the prefemur, femur and tibia, with a single saw tooth on tarsus 1. This is not the case, however, in *K. atypus* Chamberlin, 1943 which shows characters typical of many *Cryptops* species and may be a *Cryptops* with 23 leg-bearing segments. The reason why some important characters may be overlooked is discussed.

Key words. Taxonomy, Myriapoda, Chilopoda, Kethopinae, New World *Scolopendra*, *Cryptops*, *Kethops*, *Thalkethops*.

INTRODUCTION

Edgecombe (2007) reviewed the changes in schemes of scolopendromorph classification since Attems' (1930) monograph and Di et al. (2010) reviewed the Plutoniumidae showing how opinions as to the value of some morphological characters have changed.

Attems (1930) distinguished two scolopendromorph families largely on the presence or absence of ocelli, the Scolopendridae with, the Cryptopidae without. Schileyko (1992, 1995), however, regarded leg number to be of great significance recognising two suborders, the Scolopocryptopida Newport, 1844 with 23 leg-bearing segments and Scolopendrida Newport, 1844 with 21. He also considered the number of spiracles to be of major importance separating his Scolopendrida into the families Plutoniidae with 19 pairs of spiracles and Scolopendridae comprising five subfamilies: the Sterropristinae with ten pairs, i.e. spiracles on segment seven and Otostigminae, Scolopendrinae, Theatopsinae and Cryptopinae with nine, i.e. without spiracles on segment seven. The Scolopendrida thus included both blind and ocellate clades.

Shelley (2002) also regarded leg number as of fundamental importance, distinguishing the blind Scolopocryptopidae with 23 pairs of legs and Cryptopidae with 21 pairs of legs, from the ocellate Scolopendridae also with 21 pairs of legs.

A unique exception to the condition in Scolopendridae is provided by *Scolopendropsis bahiensis* (Brandt, 1841) which has 23 pairs of legs. Schileyko (2006) showed that *Rhoda calcarata* (Pocock, 1891) with 21 pairs of legs was a junior synonym of *S. bahiensis* so leg numbers can vary intraspecifically in the Scolopendridae. Vahtera et al. (2013) have shown that the Plutoniumidae with 21 trunk segments nest within the Scolopocryptopidae with 23.

With respect to spiracle number, Di et al. (2010) described *Theatops chuanensis* Di, Cao, Wu, Yin, Edgecombe et Li, 2010 (Plutoniumidae) which has well developed spiracles on segment 7. These are absent in all other known species of *Theatops* Newport, 1844. They reviewed the literature and observed that evidence is increasing to indicate that the presence or absence of spiracles on segment 7 is less reliable as a phylogenetic and taxonomic character than previously thought. Subsequently Edgecombe (2012) placed *Dinocryptops* Crabill, 1953 which has spiracles on segment 7 in synonymy with *Scolopocryptops* Newport, 1844 where they are absent and Vahtera et al. (2013) showed that *Tidops* Chamberlin, 1915 which lacks segment 7 spiracles nests within *Newportia* Gervais, 1847 which has them.

Vahtera et al. (2012, 2013) concluded that the blind Scolopendromorpha (Plutoniumidae, Cryptopidae, Scolopocryptopidae) unite as a monophyletic group consistent with a single event of eye loss i.e. Attems' (1930) Cryptopidae excluding *Mimops* Kraepelin, 1903 which has a single ocellus on each side of the cephalic plate and which Lewis (2006) placed in a separate family Mimopidae. Only one species of Scolopendridae, the Vietnamese *Tonkindentus lestes* Schileyko, 1992, is blind. Vahtera et al. (2013) concluded that eye-loss may therefore only have occurred twice in the Scolopendromorpha.

Some other cases of species which show exceptions to the expected condition are discussed here as are the problematic scolopocryptopid subfamily Kethopinae. Possible reasons for underrecording of some exceptions are considered.

Additional data on American *Scolopendra* species in the Zoological Museum of Moscow University (ZMMU) kindly provided by Arkady Schileyko are incorporated.

The terminology for the external anatomy proposed by Bonato et al. (2010) is followed here.

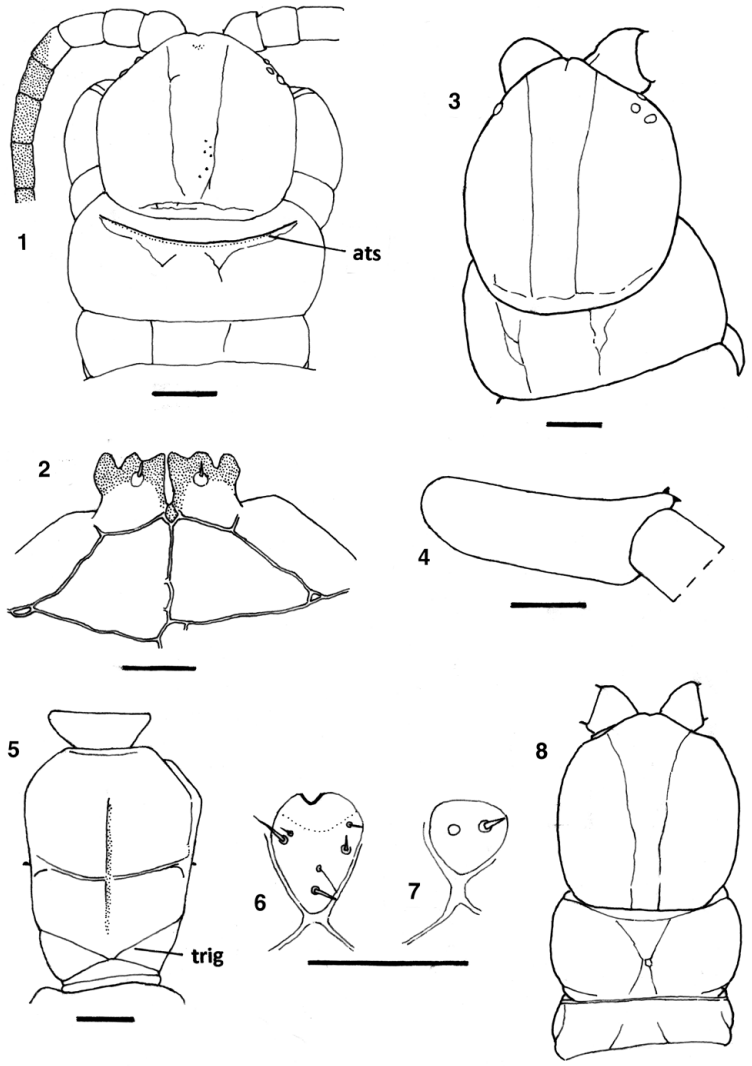
CONSISTENCY OF SOME TAXONOMIC CHARACTERS

Anterior transverse sulcus, antennal articles and legs with distodorsal prefemoral spines in American *Scolopendra* species

Analyses by Vahtera et al. (2013) resolve the New World species of *Scolopendra* Linnaeus, 1758 plus an Old World species *S. valida* Lucas, 1840, as a monophyletic group that are morphologically united by a ring furrow or groove (anterior transverse sulcus) on T1 (Fig. 1). This is von Porat's (1876) *Collaria* for which the replacement name *Nurettiniella* was proposed by Özdikmen (2007: see Vahtera et al. 2013 for details). Vahtera et al. (2013) concluded that there is a single origin of the ring furrow in Scolopendrini. In addition, most New World *Scolopendra* species have transverse and often also longitudinal sutures on the forcipular coxosternum (Fig. 2). Old World *Scolopendra* species (except *S. valida*) lack the transverse sulcus although the longitudinal sutures may be developed to a greater or lesser extent in some.

Fourteen of the 16 New World *Scolopendra* species have an anterior transverse sulcus on T1. However, *Scolopendra alternans* Leach, 1813 which clearly belongs to this group lacks this sulcus, it having failed to develop. Attems (1930) noted that the normally associated longitudinal sutures are scarcely visible. They are absent in small specimens from the US Virgin Islands (Lewis 1989), present, but very fine, in large specimens (Fig. 3). In a second species, *Scolopendra arthrorhabdoides* Ribaut, 1912 there are, according to Attems (1930), merely traces of the anterior transverse sulcus. It is absent in specimens from Colombia (Chagas Jr. et al. 2014). Arkady

Schileyko (personal communication) reports that whereas *S. pachygnatha* Pocock, 1895 and *S. viridicornis* have a solid/continuous and well-developed anterior transverse "suture", in *S. crudelis* C. L. Koch, 1847 it is thin, discontinuous and branching. Paradoxically Kraepelin (1903) in



Figs 1–8. 1 – *Scolopendra valida*: Al Mindak, Saudi Arabia. Cephalic plate and tergites 1 and 2 after Lewis (1986), ats – anterior tranverse sulcus. 2 – *S. valida*: Kassala, Sudan. Coxosternal tooth plates after Lewis (1967). 3 – *S. alternans*: Cueva de Murcielagos, Cuba; leg. P. Beron. Cephalic plate and tergite 1. 4 – *S. valida*: W. Daykah, Saudi Arabia. Prefemur of leg 20. 5 – *Cryptops* (*Trigonocryptops*) *loveridgei*: Mbara, Tanzania. Sternite 5 after Lewis (2005), trig – trigonal sutures. 6 – *C.* (*T.*) *loveridgei*: Mbara, Tanzania. Clypeal setose plate. 7 – *C. anomalans*: Chapeltown, Sheffield, UK. Clypeal setose plate. 8 – *C. anomalans*: Cephalic capsule and tergites 1 and 2 after Eason (1962). Scale bars: Fig. 1 … 2 mm. Fig. 2, 3 & 4 … 1 mm. Fig. 5 … 0.5 mm. Figs. 6 & 7 … 0.25 mm.

Table 1. Some characters of New World *Scolopendra* species and *Scolopendra valida*. Based on data from Attems (1930), Shelley (2002), Minelli (2006) and Schileyko (personal communication). Atypical characters in bold

species	anterior transverse sulcus on T1	antennal articles	transverse coxosternal suture	legs with distodorsal pre-femoral spines
Scolopendra alternans	**absent**	17	present	19–21
Scolopendra angulata	present	17	present	19–21
Scolopendra armata	present	17	present	19–21
Scolopendra arthrorhabdoides	**absent**	17	present	20, 21
Scolopendra crudelis	present	17–**18**	present	19–21
Scolopendra galapagoensis	present	17	present	2–21
Scolopendra gigantea	present	17	present	1/2–21
Scolopendra hermosa	present	17	present	18–21
Scolopendra robusta	present	17	present	**21 only**
Scolopendra viridicornis	present	17	present	varies from 1–21 to 20, 21
Scolopendra valida	present	**19–27**	present	19–21
Scolopendra heros	present	24–26	present	21 only
Scolopendra pachygnatha	present	25	**absent**	21 only
Scolopendra polymorpha	present	(21)25–31	**absent**	21 only
Scolopendra pomacea	present	**17**–18	**absent**	21 only
Scolopendra sumichrasti	present	23–26	present	21 only
Scolopendra viridis	present	21–31	**absent**	21 only

a footnote on page 226 noted that he found in the Paris Museum a typical *Scolopendra morsitans* Linnaeus, 1758 from Peking with a clear anterior transverse sulcus (*Halsringfurche*).

Lewis (2000) observed that the 10 New World *Scolopendra* species with 17 antennal articles have distodorsal spines on the prefemora of some of legs 1–20 in addition to those on the prefemoral process on the ultimate pair of legs (Fig. 4). Shelley (2002, Figs. 42–48) illustrates those of *S. alternans*. *Scolopendra robusta* Kraepelin, 1903 is an exception in lacking them. In most species they are confined to leg pairs 19 and 20 but are present on most legs in *S. galapagoensis* Bollman, 1889, *S. gigantea* Linnaeus, 1758 (illustrated by Shelley & Kiser, 2000) and on many or few in *S. viridicornis* Newport, 1844 (2–21 in ZMMU specimens from Brazil). Several species have, in addition, distodorsal femoral spines on some legs. ZMMU specimens NN6767 and 6768 of *S. crudelis* C. L. Koch, 1847 from Hispaniola have 17 or (atypically) 18 antennal articles and transverse coxosternal sutures not previously noted for the species.

Scolopendra valida, whose range extends from the Canary Islands to India, also has dorsal prefemoral spines on legs 19 and 20 but, in contrast to the New World forms, has variable number of antennal articles (19–27) rather than 17. Pocock (1888) noted that it "possesses characters which seem to point to relationship between it and some species from South America".

A second group of six species with a variable antennomere number (18–27) lack dorsodistal prefemoral spines on legs 1–20 (Table 1). The Mexican *Scolopendra pomacea* C. L. Koch, 1847 exceptionally has only 17 or 18 antennal articles. ZMMU specimens N6776 and N6777 of *S. pachygnatha* Pocock, 1895 from Jamaica have 19+20 and 18+18 antennal articles respectively (Attems, 1930 gave 25). Both specimens lack transverse coxosternal sutures (not previously recorded).

Species with 17 antennal articles are South and Central American, those with more than 17 North and Central American (Table 2). The inadequately described *Scolopendra hirsutipes* Bollman, 1893

from the West Indies is a possible member of the second group. The holotype is lost and Shelley (2002) regarded it as a junior synonym of *S. alternans*. It lacks an anterior transverse sulcus as does *S. alternans* but has 25–27 antennal articles. *Scolopendra alternans* has 17 so it seems unlikely that they are the same species. Mercurion (2016) is also of the opinion that *S. hirsutipes* is not *S. alternans* and suggests that *S. alternans* is probably an evolving species group.

Trigonal sutures in *Cryptops* (*Trigonocryptops*)

Verhoeff (1906) characterised his genus *Trigonocryptops*, as having paratergites clearly delimited, clypeus delimited by a triangular suture, a transverse thickening on the sternites between the coxae and endosternites delimited anteriorly by crossed (trigonal) sutures. Also a projection on each of the anterior corners of the endosternites, spiracles slit-like, the katopleure divided and all legs with divided tarsi. Another character shared by members of *Cryptops* (*Trigonocryptops*) is an anterior setose area on the clypeus delimited by sutures (Edgecombe 2005). Typical examples of the trigonal sutures and the anterior setose area on the clypeus are shown for *C.* (*Trigonocryptops*) *loveridgei* Lawrence, 1953 in Figs 5 and 6 respectively.

Attems (1930) pointed out that the tarsi of walking legs were not always divided and the head overlies T1 which has an anterior transverse suture, but these characters are seen in some *Cryptops* (*Cryptops*) Leach, 1815 species. Details of the endosternites are best seen in cleared specimens.

Vahtera et al (2013) drawing either upon morphological characters, molecular data or their combination for four species of *C.* (*Trigonocryptops*) concluded that the subgenus is monophyletic. Morphologically, the species analysed are united by shared presence of sternal trigonal sutures. However, Lewis (2005) synonymised *Paratrigonocryptops* Demange, 1963 from Mont Nimba, Guinea which comprises *C.* (*P.*) *royi* Demange, 1963, *C.* (*P.*). *quadrisulcatus* Demange, 1963, and *C.* (*P.*) *quadrisulcatus uncinulus* Demange, 1963 under *Cryptops* (*Trigonocryptops*) arguing that trigonal sutures can be very poorly developed and that Demange's species were, in fact, *Trigonocryptops* in which they were not expressed.

Table 2. Distribution of New World *Scolopendra* species and *Scolopendra valida*

species	distribution
Scolopendra alternans	South Florida, USA, West Indies, Venezuela, Brazil
Scolopendra angulata	West Indies, Venezuela, Bolivia, Ecuador, Brazil
Scolopendra armata	Venezuela, Brazil
Scolopendra arthrorhabdoides	Colombia
Scolopendra crudelis	West Indies
Scolopendra galapagoensis	Cocos Island, Galapagos; Costa Rica, Ecuador to S. Peru
Scolopendra gigantea	Venezuela. Records from the West Indies, Mexico and Honduras probably due to accidental human introduction
Scolopendra hermosa	Peru
Scolopendra robusta	Mexico
Scolopendra viridicornis	Colombia and Surinam to Argentina
Scolopendra valida	Canary Islands, Cameroon, through Northeast Africa to Saudi Arabia, Iran and India
Scolopendra heros	USA, Mexico
Scolopendra pachygnatha	Mexico, Jamaica
Scolopendra polymorpha	USA, Mexico, Hawaii (imported)
Scolopendra pomacea	Mexico
Scolopendra sumichrasti	Mexico Guatemala, Honduras, Panama
Scolopendra viridis	USA to Panama, Pearl Islands

Trigonocryptops characters in *Cryptops anomalans*

Cryptops anomalans Newport, 1844 shows some of the morphological characters of *Trigonocryptops*. The most detailed description is that of Brolemann (1930) as *Cryptops savignyi*, Leach 1817. The species has the clypeus clearly delimited by a triangular suture and an anterior setose area on the clypeus with two setae also delimited by sutures (Fig. 7). These are also figured by Eason (1964) and for the holotype of *C. savignyi* by Lewis (2014). The anterior segments have well-developed endosternites with a projection on each of the anterior corners figured both by Brolemann and Eason. Brolemann's Fig. 336 shows what appear to be faint traces of trigonal sutures on S5 but these have not been recorded by other workers. He wrote that they gradually disappear from S7. Examination of a British specimen shows that the spiracles are oval rather than slit-like. Further sampling may show that the separation of the two subgenera *Cryptops* and *Trigonocryptops* may not be as clear cut as current research indicates. *Cryptops* (*Trigonocryptops*) *iporangensis* de Ázara et Ferreira, 2013, from Brazil, likewise only exhibits some characters of the subgenus.

Variation in the *anomalans* group of *Cryptops* (*Cryptops*)

Vahtera et al. (2013) reported some conflict is present between existing groupings of *Cryptops* (*Cryptops*) i.e. the *hortensis*, *doriae* and *anomalans* groups proposed by Lewis (2011, 2013) and their molecular trees. They showed that there is a well-supported clade that unites *C. hortensis* Donovan, 1810 and *C. parisi* Brolemann, 1920, of the *hortensis*-group with *C. anomalans*, and *C. punicus* Sivestri, 1896, of the *anomalans* group contradicting the morphological analyses. The term *anomalans* group was proposed for those species with an anterior transverse suture on tergite 1. It is here retained for convenience of reference. There are about 78 species in the group.

The presence of an anterior transverse suture on T1 tends to be associated with cephalic sutures and various and extensive sutures on T1, the anterior part of which is usually overlain by the cephalic plate (Fig. 8). This suggests that this set of characters may be linked or it could be an example of pleiotropism. However, the anterior transverse suture may be absent in some populations. For example *Cryptops dentipes* Lawrence, 1960 from Ankaratra, Madagascar has only a median longitudinal depression on T1 but a specimen from Tananarive has an anterior transverse suture (*sillon collaire*) but no central depression (*fossette*) (Lawrence 1960). *Cryptops vanderplaetseni* Demange, 1963 has a central crescentic depression and only lateral traces of an anterior transverse suture on T1 but *C. vanderplaetseni* var. *perfectus* Demange, 1963 has a complete anterior transverse suture. According to Kraepelin (1903) the head plate generally overlaps the anterior margin of T1 in *C. galatheae* Meinert, 1886 but rarely is the reverse the case; the anterior transverse suture may be present or absent.

Kethops and *Thalkethops* (Scolopocryptopidae: Kethopinae)

The Kethopinae, a subfamily of the Scolopocryptopidae, are not well known and present some interesting problems. Edgecombe & Bonato (2011) defined the Scolopocryptopidae, as lacking ocelli, with a pectinate second maxillary claw, the forcipular coxosternite without prominent serrate tooth-plates, but having at most a few small teeth and the number of leg-bearing segments invariably 23. The gizzard with stiff, pineapple-shaped projections, the main zone of projections having a kink near their midlength. The subfamily Kethopinae was erected by Shelley (2002) to receive *Kethops* Chamberlin, 1912, and *Thalkethops* Crabill, 1960. The subfamily he defined as having the ultimate legs curled and incrassate i.e. like *Cryptops*, second tarsi [of ambulatory legs] not redivided and prefemora of ultimate legs with more than one ventral spine [presumably saw tooth] apiece.

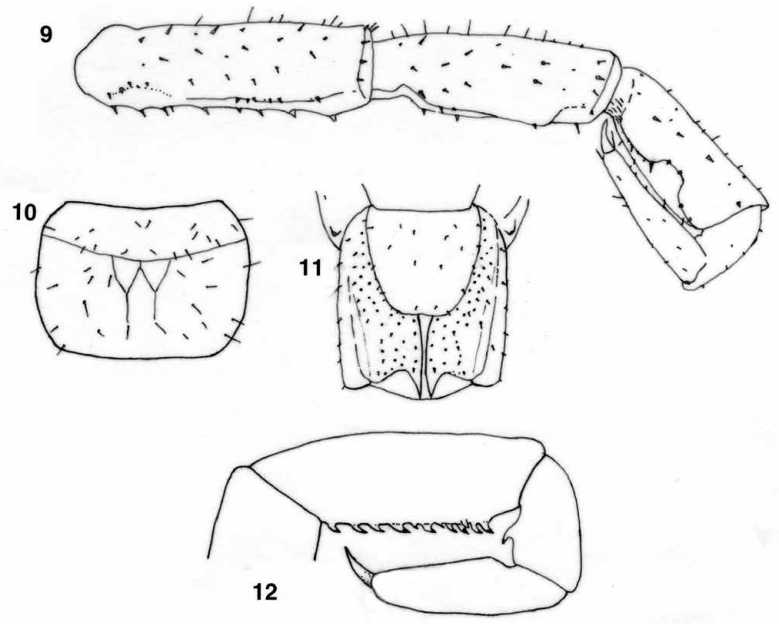
The type species of *Kethops*, *Kethops utahensis* (Chamberlin, 1909) was originally described as a *Newportia*. However, the specimen lacked ultimate legs. Chamberlin described a second

specimen with ultimate legs in 1912. The description of the legs is puzzling "prefemur of anal legs armed with rows of spines on mesal and ectal surface and on most of the ventral. Femur similarly armed mesally and ventrally. The tibia with similar spines ventrally. Tarsi composed of but two joints and ending in a distinct and very stout claw." Chamberlin's Fig. 6 shows what appear to be short spinous setae rather than saw teeth (Fig. 9).

Crabill (1958) says of *Kethops* "Their diminutive size and pale colour, their suturation, their lack of prehensorial plates and denticles and their remarkable rear legs, which are almost identical with the type found in the Cryptopinae, all suggest a very close affinity with ... this subfamily despite the discrepancy in pedal segments between the two groups (23 vs 21)." However the claw of 2nd maxillary telopodite is pectinate (in his *K. euterpe* Crabill, 1958) as in other Scolopocryptopidae as he noted was the also the case for *Thalkethops* (Crabill, 1960). The gizzard morphology of *K. utahensis* shows scolopocryptopid characters (Koch et al. 2009) as does the morphology of the peristomatic region (Edgecombe & Koch 2008).

Shelley (2002) synonymised *Kethops leioceps* Chamberlin, 1925, *Cryptops colomanus* Chamberlin, 1941, *Cryptops glenvilleus* Chamberlin, 1941 and *Kethops euterpe* under *Kethops utahensis*. That Chamberlin having described *Kethops* should then have described two "*Cryptops*" species from California is surprising. Shelley (2002) examined the holotypes and finding that they have 23 pairs of legs synonymised them under *Kethops*, and concluded (e-mail dated 21 November 2013) that Chamberlin "didn't even bother to count the legs".

Shelley (2002) in his diagnosis of *K. utahensis* gives maximum length 27 mm, cephalic plate overlapping T1, with cervical groove (anterior transverse suture) giving rise to sutures in "W"



Figs 9–12. 9 – *Kethops utahensis*: ultimate leg after Chamberlin (1912). 10 – *K. euterpe* (= *utahensis*): tergite 1 after Crabill (1958). 11 – *K. utahensis*: ultimate leg bearing segment, ventral after Chamberlin (1912). 12 – *Thalkethops grallatrix*: tibia and tarsi of ultimate leg after Crabill (1960).

Table 3. Numbers of saw teeth on the articles of the ultimate pair of legs of the species of Kethopinae. ND = No data. Atypical numbers in bold

	prefemur	femur	tibia	tarsus 1
Kethops utahensis synonyms[1]				
Kethops leioceps Chamberlin, 1925	4	4	a series	ND
Cryptops colomanus Chamberlin, 1941	**0**	3	12	1
Cryptops glenvilleus Chamberlin, 1941	3	3	7	1
Kethops euterpe Crabill, 1958	3	3–4	9–10	1
Thalkethops grallatrix Crabill, 1960	7	12	11	1
Kethops atypus Chamberlin, 1943	**0**	**0**	6	**3**

[1] Chamberlin's (1912) description of the ultimate legs of *K. utahensis* is confusing.

configuration (Fig. 10). Further details are given in Crabill's (1958) description of *K. euterpe*: sternites with pronounced submarginal sulci, coxopleuron with a "spine", presumably a process, with 3 small spines. Chamberlin (1912) illustrated this "process" in his *K. utahensis* (Fig. 11). The ultimate legs of *K. euterpe* have 3 saw teeth on the prefemur, 3 or 4 on the femur, 9 or 10 on the tibia and one on the tarsus. Crabill (1958) used the term spine for saw tooth. *Thalkethops grallatrix* Crabill, 1960 is not dissimilar to *K. euterpe* having 7 prefemoral, 12 femoral, 11 tibial saw teeth and one on tarsus 1. The sternites lack submarginal sulci and there is a short spinous coxopleural process.

Apart from Chamberlin's (1912) puzzling Fig. 6, the only figures of the ultimate legs of Kethopinae are Crabill's (1958) Fig. 3 of the tibia and tarsus 1 and 2 of his *K. euterpe* and his Fig. 15 (Crabill 1960) of the tibia and tarsus 1 and 2 of *T. grallatrix* (Fig. 12). As the prefemur and femur were not illustrated by Crabill, I initially thought that only the tibia and tarsus 1 bore saw teeth.

Chamberlin's terminology for the articles of the ultimate leg in his "species" is confusing. For his *Cryptops colomanus* he gave "third joint [prefemur] of anal legs with numerous short spines beneath ... fourth joint [femur] with longer, stout setae beneath but no spines, bearing a longitudinal series of three widely separated teeth, the fifth joint [tibia] with a series of 12 teeth beneath, and the first tarsal joint with one." For *Cryptops glenvilleus* he gave "third joint [prefemur] of anal legs with a longitudinal series of three well spaced teeth ... fourth joint [femur] with three well spaced teeth ... the fifth joint [tibia] with a comb like series of seven teeth and the first tarsal joint with one tooth beneath".

In Chamberlin's "*K. leioceps*" "The anal legs in general as *utahensis* ... femur [prefemur] toward mesal side of ventral surface a series of four stout spines or teeth. Tibia [femur] also with a series of four ventral teeth. Metatarsus [tibia] with a ventral series of close-set teeth, not with an edge excised in the middle as in *utahensis*".

The distribution of saw teeth described for the various *K. utahensis* specimens and for *K. atypus* Chamberlin, 1943 and *T. grallatrix* is shown in Table 3.

Kethops atypus is quite unlike *K. utahensis*. Shelley's (2002) figure 145 of the holotype shows the cephalic plate, which lacks sutures, is overlapped by T1 which also lacks sutures. Chamberlin gave cephalic plate overlapping the first tergite! Chamberlin made no mention of sternite submarginal sulci which are present in *K. utahensis* nor of a coxopleural process and described the ultimate leg spinulation as metatarsus [tibia] armed beneath with a series of six teeth, the first tarsal joint with a series of three teeth. These are, apart from the fact that there are 23 pairs of legs, characters of many *Cryptops* species. There are no data on the maxillae, gizzard or peristomatic region. Further data are required but it is possible that this is uniquely a *Cryptops* with 23 pairs of legs.

If this is so, then we might categorise *Kethops* as having the ultimate legs with (0)3–4 prefemoral, 3–4 femoral, 7–12 tibial saw teeth and a single saw tooth on tarsus 1. In *Thalkethops* there are numerous prefemoral, femoral and tibial saw teeth but, again only a single saw tooth on tarsus 1. The remarkable and unique Brazilian *Cryptops* (*Cryptops*) *spelaeoraptor* de Ázara et Ferreira, 2014 has numerous saw teeth on all articles of the ultimate legs.

DISCUSSION

Key characters such as the anterior transverse sulcus on T1 in American *Scolopendra* species may not always be expressed. Similarly 35 or the 36 species of *Newportia* reviewed by Schileyko and Minelli, 1998 have an anterior transverse suture on T1 but in one, *Newportia sargenti* Chamberlin, 1958 from Venezuela the suture is absent. It may also be the case that some *Trigonocryptops* lack the usually characteristic trigonal sutures. As the number of scolopendromorph species surveyed increases so the exceptions lacking "key" characters appear. As noted above Di et al 2010 observed that evidence is increasing to indicate that the presence or absence of spiracles on segment 7 is less reliable as a phylogenetic and taxonomic character than previously thought.

It is possible that characters such as the presence, or absence of spiracles on leg bearing segment 7 are under recorded. I tend not to check for these in specimens in which the genus is obvious, for example, species of *Scolopendra*, *Asanada* or *Cryptops*. However, I always check for these in *Otostigmus/Rhysida*–like material which, as Kraepelin (1903) pointed out, possess the same 'Habitus' and are differentiated solely by the presence of these spiracles: present on segment 7 in *Rhysida*, absent in *Otostigmus*. However, in a study of the life history and distribution of *Rhysida nuda togoensis* Kraepelin, 1903 (= *R. immarginata togoensis*) in Nigeria (Lewis, 1972) having satisfied myself as to the genus and species, I did not check all 85 specimens for the presence of spiracles on segment 7. Specimens with an unexpected number of leg-bearing segments may also be overlooked which appears to have been the case when Chamberlin (1941) mistook specimens of *Kethops* for *Cryptops*.

The tendency is to check characters expected to vary such as number of antennal articles and legs with tarsal spurs but not to check those expected to be constant such as number of leg-bearing segments. Other characters may be overlooked for example the presence of a saw tooth or teeth on the ultimate leg femur in several *Cryptops* species (Lewis 2011). This problem was recognised by Ribaut (1923), who, when discussing the distinction between *C. neocaledonicus* Ribaut, 1923 and *C. megaloporus* Haase, 1887, pointed out that in *C. megaloporus* the ventral femoral [saw] tooth is not apparent but it may have been overlooked as it is difficult to recognise it amongst spiniform setae.

Some characters appear spasmodically in several genera. For example W-shaped sutures on T1 occur in *Cryptops angolensis* Machado, 1951, *C. mirabilis* Machado, 1951 and in some *Newportia*, *Tidops* and *Kethops;* this suggests that they are of little adaptive value.

Vahtera et al. (2013) have shown that the Plutoniumidae with 21 leg-bearing segments nests within the Scolopocryptopidae with 23. It is here suggested that *Kethops atypus* with 23 pairs of legs may be a *Cryptops*, species which otherwise have 21.

Acknowledgements

My thanks are due to Greg Edgecombe for his very helpful discussions on several matters; to Arkady Schileyko and Karel Tajovský for their constructive reviews of this paper and also to Arkady Schileyko for providing his personal observations on relevant specimens in the Zoological Museum of Moscow University. Thanks also to Rowland Shelley for information on *Kethops* and to Michael Baker for processing the figures.

REFERENCES

Attems G. 1930: *Scolopendromorpha*. *Das Tierreich 54*. Berlin-Leipzig: Walter de Gruyter & Co., 308 pp.

de Ázara L. N. & Ferreira R. L. 2013: The first troglobitic Cryptops (Trigonocryptops) (Chilopoda: Scolopendromorpha) from South America and the description of a non-troglobitic species from Brazil. *Zootaxa* **3709**: 432–444.

de Ázara L. N. & Ferreira R. L. 2014: Cryptops (Cryptops) spelaeoraptor n. sp. a remarkable troglobitic species (Chilopoda: Scolopendromorpha) from Brazil. *Zootaxa* **3826**: 291–300.

Bonato L., Edgecombe G. D., Lewis J. G. E., Minelli A., Pereira L. A., Shelley R. M. & Zapparoli M. 2010: A common terminology for the external anatomy of centipedes (Chilopoda). *ZooKeys* **69**: 17–51.

Broleman H.-W. 1930: *Éléments d'une Faune des Myriapodes de France*. *Chilopodes*. Paris: Comité Faune de France, xx+405 pp.

Chagas Jr. A., Chaparro E., Jiménez S. G., Triana H. D. T., Flórez D. E. & Seoane J. C. S. 2014: The centipedes (Arthropoda, Myriapoda, Chilopoda) from Colombia: Part I. Scutigeromorpha and Scolopendromorpha. *Zootaxa* **3779**: 133–156.

Chamberlin R. V. 1909: A Newportia in Utah. *Canadian Entomologist* **41**: 27–30.

Chamberlin R. V. 1912: New North American chilopods and diplopods. *Annals of the Entomological Society of America* **5**: 141–172+x–xiii.

Chamberlin R. V. 1925: Notes on some centipeds and millipeds from Utah. *Pan-Pacific Entomologist* **2**: 55–63.

Chamberlin R. V. 1941: Three new cryptopids of the genus Cryptops. *Pomona College Journal of Entomology and Zoology* **33**: 41–42.

Chamberlin R. V. 1943: Some records and descriptions of American chilopods. *Proceedings of the Biological Society of Washington* **56**: 97–108.

Crabill R. E. Jr. 1958: A new Kethops from New Mexico, with a key to its congeners. *Proceedings of the Entomological Society of Washington* **60**: 235–238.

Crabill R. E. Jr. 1960: A new American genus of cryptopid centipedes, with an annotated key to the scolopendromorph genera of America North of Mexico. *Proceedings of the United States National Museum* **111**: 1–15.

Demange J.-M. 1963: Chilopoda. La Réserve Naturelle Intégrale du Mont Nimba. *Memoires de l'Institut Français d'Afrique Noire* **66**: 41–118.

Di Z. Y., Cao Z. J., Wu Y. L., Yin S. J., Edgecombe G. D. & Li W. X. 2010: Discovery of the centipede family Plutoniumidae (Chilopoda) in Asia: a new species of Theatops from China, and the taxonomic value of spiracle distributions in Scolopendromorpha. *Zootaxa* **2667**: 51–63.

Eason E. H. 1964: *Centipedes of the British Isles*. London & New York: Frederick Warne & Co Ltd, x+294 pp.

Edgecombe G. E. 2005: A troglomorphic species of the centipede Cryptops (Trigonocryptops) (Chilopoda: Scolopendromorpha) from Western Australia. *Records of the Western Australian Museum* **22**: 315–323.

Edgecombe G. E. 2007: Centipede systematics: progress and problems. In: Zhang Z.-Q. & Shear W. A. (eds): *Linnaeus Tercentenary*: *Progress in Invertebrate Taxonomy*. *Zootaxa* **1668**: 327–341.

Edgecombe G. E. & Bonato L. 2011: Chilopoda – taxonomic overview. Order Scolopendromorpha. Pp.: 392–407. In: Minelli A. (ed.): *Treatise on Zoology – Anatomy*, *Taxonomy*, *Biology. The Myriapoda. Volume 1*. Leiden: Brill, 546 pp.

Edgecombe G. E. & Koch M. 2008: Phylogeny of scolopendromorph centipedes (Chilopoda): morphological analysis featuring characters from the peristomatic area. *Cladistics* **24**: 872–901.

Edgecombe G. D., Vahtera V., Stock S. R., Kallonen A., Xiao X., Rack A. & Girbet G. 2012: A scolopocryptopid centipede (Chilopoda: Scolopendromorpha) from Mexican amber: synchrotron microtomography and phylogenetic placement using a combined morphological and molecular data set. *Zoological Journal of the Linnean Society* **166**: 768–786.

Koch M., Pärschke S. & Edgecombe G. D. 2009: Phylogenetic implications of gizzard morphology in scolopendromorph centipedes (Chilopoda). *Zoologica Scripta* **38**: 269–288.

Kraepelin K. 1903: Revision der Scolopendriden. *Mitteilungen aus dem Nauturhistorischen Museum in Hamburg* **20**: 1–276.

Lawrence R. F. 1960: *Myriapodes Chilopodes. Faune de Madagascar 12*. Tananarive-Tsimbazaza: Institut de Recherche Scientifique, 121 pp.

Lewis J. G. E. 1972: The life histories and distribution of the centipedes Rhysida nuda togoensis and Ethmostigmus trigonopodus (Scolopendromorpha: Scolopendridae) in Nigeria. *Journal of Zoology*, *London* **167**: 399–414.

Lewis J. G. E. 1989: The scolopendromorph centipedes of St John, U.S. Virgin Islands collected by Dr W. B. Muchmore. *Journal of Natural History* **23**: 1003–1016.

Lewis J. G. E. 2000: Centipede antennal characters in taxonomy with particular reference to scolopendromorphs and antennal development in pleurostigmomorphs (Myriapoda, Chilopoda). *Fragmenta Faunistica* **43**(Supplement): 87–96.

Lewis J. G. E. 2005: A reassessment of Cryptops loveridgei Lawrence and C. kivuensis Lawrence, with observations on the subgenera Trigonocryptops Verhoeff and Paratrigonocryptops Demange (Chilopoda, Scolopendromorpha). *African Invertebrates* **46**: 115–124.

Lewis J. G. E. 2006: On the scolopendromorph centipede genus Mimops Kraepelin, 1903, with a description of a new family (Chilopoda: Scolopendromorpha). *Journal of Natural History* **40**: 1231–1239.

Lewis J. G. E. 2011: A review of the species of the genus Cryptops Leach, 1815 from the Old World related to Cryptops (Cryptops) hortensis (Donovan, 1810) (Chilopoda, Scolopendromorpha). *International Journal of Myriapodology* **4**: 11–50.

Lewis J. G. E. 2013: A review of the species in the genus Cryptops Leach, 1815 from the Old World and Australasia related to Cryptops (Cryptops) doriae Pocock, 1891 (Chilopoda: Scolopendromorpha: Cryptopidae). *Zootaxa* **3683**: 1–34.

Lewis J. G. E. 2014: On the status of Cryptops savignyi Leach, 1817, and Cryptops anomalans Newport, 1844, (Chilopoda: Scolopendromorpha: Cryptopidae). *Bulletin of the British Myriapod and Isopod Group* **27**: 30–35.

Mercurio R. J. 2016: Resurrection of Scolopendra longipes Wood and Scolopendra cubensis Saussure from synonymy with Scolopendra alternans Leach (Chilopoda, Scolopendromorpha, Scolopendridae): an enigmatic species-group needing phylogeographic analysis, with an overview on the origin and distribution of centipedes in the Carribean region. *Zootaxa* **4111**: in press.

Minelli A. (ed.) 2006: *Chilobase: A World Catalogue of Centipedes* (*Chilopoda*) *for the Web*. URL: chilobase.bio.unipd.it. (Accessed 15.06.2014).

Özdikmen H. 2007: A nomenclatural act on Myriapoda: replacement names for homonymous generic names of a millipede and a centipede (Myriapoda: Diplopoda and Chilopoda). *Munis Entomology & Zoology* **2**: 433–435.

Pocock R. I. 1888: Description of Scolopendra valida with notes on allied species. *Annals and Magazine of Natural History*, *Sixth Series* **1**: 335–340.

von Porat C. O. 1876: Om några exotiska Myriopoder. *Bihang till Kongliga Svenska Vetenskaps-Akadamien Handlingar* **4**(7): 1–48.

Ribaut H. 1923: Chilopodes de la Nouvelle Calédonie et des Iles Loyalty. In: Sarasin F. & Roux J. (eds): *Nova Caledonia. Forschungen in Neu-Caledonien und auf den Loyalty Inseln* **3**: 1–79.

Schileyko A. A. 1992: The scolopenders of Viet-Nam and some aspects of the system of Scolopendromorpha (Chilopoda Epimorpha) Part 1. *Arthropoda Selecta* **1**: 5–19.

Schileyko A. A. 1995: The scolopendromorph centipedes of Vietnam (Chilopoda Scolopendromorpha) Part 2. *Arthropoda Selecta* **4**: 73–87.

Schileyko A. A. 2006: Redescription of Scolopendropsis bahiensis (Brandt, 1841), the relations between Scolopendropsis and Rhoda, and notes on some characters used in scolopendromorph taxonomy (Chilopoda: Scolopendromorpha). *Arthropoda Selecta* **15**: 9–17.

Schileyko A. A. & Minelli A. 1998: On the genus Newportia Gervais, 1847 (Chilopoda: Scolopendromorpha: Newportiidae). *Arthropoda Selecta* **7**: 265–299.

Shelley R. M. 2002: A Synopsis of the North American Centipedes of the order Scolopendromorpha (Chilopoda). *Virginia Museum of Natural History Memoir*, *Martinsville* **5**: viii+108 pp.

Shelley R. M. & Kiser S. B. 2000: Neotype designation and a diagnostic account of the centipede, Scolopendra gigantea L. 1758, with an account of S. galapagoensis Bollman 1889 (Chilopoda Scolopendromorpha Scolopendridae). *Tropical Zoology* **13**: 159–170.

Vahtera V., Edgecombe G. D. & Giribet G. 2012: Evolution of blindness in scolopendromorph centipedes (Chilopoda: Scolopendromorpha): insight from an expanded sampling of molecular data. *Cladistics* **28**: 4–20.

Vahtera V., Edgecombe G. D. & Giribet G. 2013: Phylogenetics of scolopendromorph centipedes: Can denser taxon sampling improve an artificial classification? *Invertebrate Systematics* **27**: 578–602.

Verhoeff K. W. 1906: Vergleichendmorphologische Studie über die coxopleuralen Körperteile der Chilopoden, mit besonderer Berücksichtigung der Scolopendromorpha, ein Beitrag zur Anatomie und Systematik derselben nebst physiologischen und phylogenetischen Mitteilungen und Ausblicken auf die Insekten. *Nova Acta Academiae Leopoldino-Carolinae Germanicum Naturae Curiosorum* **86**: 349–501.

Acta Soc. Zool. Bohem. **80**: 33–37, 2016
ISSN 1211-376X

An annotated checklist of the millipedes (Diplopoda) recorded in the Czech Republic

Karel Tajovský[1)] & Ivan Hadrián Tuf[2)]

[1)] Biology Centre CAS, Institute of Soil Biology, Na Sádkách 7, CZ–370 05 České Budějovice, Czech Republic; e-mail: tajov@upb.cas.cz
[2)] Department of Ecology and Environmental Sciences, Faculty of Science, Palacký University, Šlechtitelů 27, CZ–779 00 Olomouc, Czech Republic

Received 26 June 2015; *accepted 23 October 2015*
Published 12 April 2016

Abstract. The present checklist summarises information on millipede species recorded in the Czech Republic. The previously published lists are updated by incorporating published and revised data about the millipede fauna of the Czech Republic. Altogether, the checklist of millipedes includes 77 species.

Key words. Catalogue, Diplopoda, Glomerida, Chordeumatida, Julida, Polyxenida, Polyzoniida, Polydesmida, Czech Republic.

INTRODUCTION

The knowledge of the millipede fauna of the Czech Republic has a long history and is closely associated with research on this invertebrate group in surrounding Central European countries. The first papers dealing with millipedes were published in this country at the end of the 19th century (Wankel 1861, Fickert 1875, Rosický 1876, Uličný 1883). In addition, information from Bohemia, Moravia and Silesia (i.e. the main geographically historical parts of the Czech Republic) are included in historical monographs published by Latzel (1884) and Haase (1886, 1887) and authors other than the above mentioned zoologists, such as B. Němec, K. W. Verhoeff, B. Folkmanová, J. Homoláč and V. Borek, also significantly contributed to the knowledge of Czech millipedes during the first half of the 20th century. The first thorough overview of our fauna that included most of the previously published data was presented by Lang (1933, 1954). Based on an evaluation of his work, Gulička (1985) proposed a new list of the millipedes in the Czech fauna, which was more critical and comprehensive than previous lists. A new phase of research started in the nineties of the past century, which is connected with following researchers: J. Čepera, J. Gulička, P. Kocourek, E. Kula, M. Lazorík, K. Tajovský, J. Tufová (nee Ožanová) and I. H. Tuf, and their students. In addition, there were many new records collected during the last few decades based on intensive monitoring of protected areas and nature reserves throughout the whole country and sampling in diverse suburban habitats, including greenhouses and large cities. After Tajovský (2001) published his overview of Czech millipedes and all the historical literary sources, summary lists of millipedes complemented by new records, appeared in several studies reported by Kocourek (2001, 2013) and Tuf & Tufová (2008). The checklist presented here summarises published as well as unpublished data and records, and includes all the species recorded in the Czech Republic.

MATERIALS AND METHODS

The checklist is based on the last published lists (Tajovský 2001, Kocourek 2001, 2013, Tuf & Tufová 2008). Taxonomy follows the database of the Fauna Europaea (Enghoff & Kime 2013). New records of millipedes announced here use the faunistic square codes (FSC) for the mapping of their distribution in the Czech Republic.

RESULTS

The following checklist of the millipede species reported in the Czech Republic includes 77 species. The superscript numbers at the end of the species names refer to the notes in the following text.

Polyxenida	Polyxenidae	*Polyxenus lagurus* (Linnaeus, 1758)
Glomerida	Glomeridae	*Geoglomeris subterranea* Verhoeff, 1908[1] *Glomeris connexa* C. L. Koch, 1847 *Glomeris hexasticha* Brandt, 1833 *Glomeris klugii* Brandt, 1833 *Glomeris pustulata* Latreille, 1804 *Glomeris tetrasticha* Brandt, 1833 *Trachysphaera costata* (Waga, 1857) *Trachysphaera gibbula* (Latzel, 1884)
Polyzoniida	Polyzoniidae	*Polyzonium germanicum* Brandt, 1837
Julida	Blaniulidae	*Blaniulus guttulatus* (Fabricius, 1798) *Choneiulus palmatus* (Němec, 1895) *Nopoiulus kochii* (Gervais, 1847) *Proteroiulus fuscus* (Am Stein, 1857)
	Julidae	*Allajulus nitidus* (Verhoeff, 1891) *Brachyiulus bagnalli* (Curtis, 1845) *Brachyiulus lusitanus* Verhoeff, 1898 *Cylindroiulus arborum* Verhoeff, 1928 *Cylindroiulus boleti* (C. L. Koch, 1847) *Cylindroiulus britannicus* (Verhoeff, 1891) *Cylindroiulus caeruleocinctus* (Wood, 1864) *Cylindroiulus latestriatus* (Curtis, 1845) *Cylindroiulus luridus* (C. L. Koch, 1847) *Cylindroiulus parisiorum* (Brölemann et Verhoeff, 1896) *Cylindroiulus punctatus* (Leach, 1815) *Cylindroiulus truncorum* (Silvestri, 1896) *Cylindroiulus vulnerarius* (Berlese, 1888) *Enantiulus nanus* (Latzel, 1884) *Julus scandinavius* Latzel, 1884 *Julus scanicus* Lohmander, 1925 *Julus terrestris* Linnaeus, 1758 *Kryphioiulus occultus* (C. L. Koch, 1847) *Leptoiulus cibdellus* (Chamberlin, 1921) *Leptoiulus montivagus* (Latzel, 1884) *Leptoiulus noricus* Verhoeff, 1913 *Leptoiulus proximus* (Němec, 1896) *Leptoiulus trilobatus* (Verhoeff, 1894) *Megaphyllum projectum* Verhoeff, 1894 *Megaphyllum unilineatum* (C. L. Koch, 1838) *Ommatoiulus sabulosus* (Linnaeus, 1758) *Ophyiulus pilosus* (Newport, 1842) *Pachypodoiulus eurypus* (Attems, 1895) *Rossiulus vilnensis* (Jawlowski, 1925) *Tachypodoiulus niger* (Leach, 1814)

		Unciger foetidus (C. L. Koch, 1838) *Unciger transsilvanicus* (Verhoeff, 1899)
	Nemasomatidae	*Nemasoma varicorne* C. L. Koch, 1847
Chordeumatida	Anthroleucosomatidae	*Hungarosoma bokori* Verhoeff, 1928[2]
	Brachychaeteumatidae	*Brachychaeteuma bradeae* (Brolemann et Brade-Birks, 1917)[3]
	Chordeumatidae	*Melogona broelemanni* (Verhoeff, 1897) *Melogona gallica* (Latzel, 1884) *Melogona voigtii* (Verhoeff, 1899) *Melogona transsylvanica* (Verhoeff 1897) *Mycogona germanica* (Verhoeff, 1892)
	Craspedosomatidae	*Craspedosoma rawlinsi* Leach, 1814 *Craspedosoma transsylvanicum* (Verhoeff, 1897) *Listrocheiritium septentrionale* Gulička, 1965 *Ochogona caroli* (Rothenbuehler, 1900)
	Haaseidae	*Haasea flavescens* (Latzel, 1884) *Haasea germanica* (Verhoeff, 1901) *Hylebainosoma tatranum* Verhoeff, 1899[4]
	Mastigophorophyllidae	*Haploporatia eremita* (Verhoeff, 1909) *Mastigona bosniensis* (Verhoeff, 1897) *Mastigona mutabilis* (Latzel, 1884) *Mastigophorophyllon saxonicum* Verhoeff, 1916
	Verhoeffiidae	*Haplogona oculodistincta* (Verhoeff, 1893)
Polydesmida	Macrosternodesmidae	*Macrosternodesmus palicola* Brolemann, 1908[5]
	Oniscodesmidae	*Amphitomeus attemsi* (Schubart, 1934)
	Paradoxosomatidae	*Oxidus gracilis* (C. L. Koch, 1847) *Strongylosoma stigmatosum* (Eichwald, 1830)
	Polydesmidae	*Brachydesmus superus* Latzel, 1884 *Polydesmus angustus* Latzel, 1884 *Polydesmus complanatus* (Linnaeus, 1761) *Polydesmus denticulatus* C. L. Koch, 1847 *Polydesmus inconstans* Latzel, 1884 *Propolydesmus germanicus* (Verhoeff, 1896) *Propolydesmus testaceus* (C. L. Koch, 1847)

[1] *Geoglomeris subterranea* was confirmed for the first time in catches from subterranean traps set near the Zbrašov Aragonite Caves, Teplice nad Bečvou (FSC 6472), North eastern Moravia by J. Mikula in 2005–2006 (Mikula 2006). Subsequently, it was recorded also in the Slámova sluj Abyss, the Štramberk Karst (FSC 6474), Northeast Moravia by K. Tajovský in 2006, on railway embankment at Olomouc by M. Navrátil in 2006 (Riedel et al. 2009) and also in the Zbrašov Aragonite Caves by K. Tajovský in 2007.

[2] *Hungarosoma bokori* – based on current analyses, only females of this species were recorded by P. Kocourek and K. Tajovský in forest soil at Hostěnice (FSC 6766), on the Moravian Karst. This the westernmost occurrence of this species was preliminary announced by Mock et al. (2014).

[3] *Brachychaeteuma bradeae* – after the first record of this species (Tajovský & Mlejnek 2007) it was repeatedly collected in mainly subterranean habitats in Eastern Bohemia and several Moravian karstic areas. Females apparently belonging to this species were recorded in soils in Jičín (FSC 5558), Eastern Bohemia by P. Riedel in 2006 (Riedel 2008) and an apple orchard near Starý Hrozenkov (FSC 7073), the White Carpathians Protected Landscape Area, Southeast Moravia, by K. Tajovský in 2011.

[4] *Hylebainosoma tatranum* is a Carpathian endemic species, for which there are several confirmed recordings in Eastern regions of the Beskydy Mts. (Tajovský et al. 2014).

[5] *Macrosternodesmus palicola* was first recorded in the Mladečský Karst, Central Moravia (Tajovský & Mlejnek 2007) and then in the Koněpruské Caves (FSC 6050), Bohemian Karst, Central Bohemia by K. Tajovský in 2009.

Unlike the recently published checklists of the Czech millipedes (Tajovský 2001, Kocourek 2001, 2013, Tuf & Tufová 2008), the following species are not included:

Glomeris marginata (Villers, 1789) listed by Tajovský (2001); historically announced from the Bohemian Karst (Lang 1954), but not confirmed despite intensive surveys of this area.

Craspedosoma alemannicum Verhoeff, 1910 and *C. germanicum* Verhoeff, 1910 listed by Tajovský (2001) and Tuf & Tufová (2008); the published records correspond to the species *C. rawlinsi*.

Craspedosoma slavum Attems, 1929 listed by Tajovský (2001); erroneous information previously criticized by Gulička (1985).

Haasea pinivaga Verhoeff, 1901, listed by Tajovský (2001) and Tuf & Tufová (2008), was described based on material collected in the Bohemian Forest at Teufelssee = the Devils Lake = Čertovo jezero. Based on extensive material collected directly from the locus typicus of *Haasea pinivaga* (with common occurrence of both *H. flavescens* and *H. germanica*) and in agreement with other authors (e.g. Hauser & Voigtländer 2009), *H. pinivaga* should be definitely synonymized with *H. flavescens* (Tajovský unpubl.).

Mastigona vihorlatica (Attems, 1899) listed in Tajovský (2001) and Tuf & Tufová (2008); all previous data included under *Mastigona bosniensis*.

Mastigophorophyllon alpivagum bohemicum Attems, 1900 listed in Tajovský (2001) and Tuf & Tufová (2008); questionable taxon described by Attems without a precise locality. In Fauna Europaea (Enghoff & Kime 2013), it is still treated as two separate species, *M. alpivagum* (Verhoeff, 1897) with distribution in the Czech Republic and *M. bohemicum* Attems, 1900 with no data on its distribution. No historical or recent evidence could be connected with them, therefore this taxon was not included in the checklist.

Ochogona moravica nomen nudum (Kocourek 2007) listed repeatedly by Kocourek (2013) and his student (Skoumalová 2010); the specimens were subsequently determined as *Hungarosoma bokori*; see note 2.

Summarising the available data for the Czech Republic the present checklist includes 77 species of millipedes. The increase in faunistic research over the past two decades has not resulted in many changes so it is likely that the checklist is more or less stable. However, new records are likely for some outlying areas, including records of non-native species.

Three species of millipedes (*Choneiulus palmatus*, *Leptoiulus proximus* and *Listrocheiritium septentrionale*) were described based on material from the Czech Republic. The millipede *Listrocheiritium septentrionale* is recorded mainly in the Czech Republic and only occasionally in adjacent areas in Upper and Lower Austria, and therefore can be considered as the only endemic species occurring in Central Europe other than the Alps and Carpathians.

Acknowledgements

This research was supported by a research plan of the ISB BC CAS and Internal Grant Agency of Palacký University No. PrF_2015_008.

REFERENCES

Enghoff H. & Kime D. R. 2013: *Diplopoda. Fauna Europaea Version 2.6.2*. URL: www.faunaeur.org

Fickert C. 1875: *Myriopoden und Araneiden vom Kamme des Riesengebirges. Ein Beitrag zur Faunistik des subalpinen Region Schlesiens*. Dissertation. Breslau: Philosophischen Facultaet der Koeniglichen Univesitaet Breslau, 47 pp.

Gulička J. 1985: Kritisches Verzeichnis der Diplopoden der ČSR (Böhmen/Čechy, Mähren/Morava, Schlesien/Slezsko) (Myriapoda). *Faunistische Abhandlungen des Staatlichen Museums für Tierkunde Dresden* **12**: 107–123.

Haase E. 1886: Schlesiens Diplopoden. *Zeitschrift für Entomologie*, *Breslau* **11**: 7–64.

Haase E. 1887: Schlesiens Diplopoden. Zweite Hälfte. *Zeitschrift für Entomologie*, *Breslau* **12**: 1–46.
Hauser H. & Voigtländer K. 2009: *Doppelfüßer* (*Diplopoda*) *Ostdeutschlands*. Göttingen: Deutscher Jugendbund für Naturbeobachtung, 112 pp.
Kocourek P. 2001: Several new species of millipedes (Diplopoda) from the Czech Republic. *Acta Societatis Zoologicae Bohemicae* **65**: 81–96.
Kocourek P. 2007: Mnohonožky (Diplopoda) chráněné krajinné oblasti Český kras [Millipedes (Myriapoda: Diplopoda) of the Bohemian Karst Protected Landscape Area]. *Fragmenta Ioannea Collecta*, *Zoologica* **7**: 5–42 (in Czech).
Kocourek P. 2013: Mnohonožky (Myriapoda: Diplopoda) Prahy [Millipedes (Myriapoda: Diplopoda) of Prague (Central Bohemia)]. *Natura Pragensis*, *Praha* **21**: 3–146 (in Czech, with a summary in English).
Lang J. 1933: Příspěvek k poznání československých diplopodů [Contribution to the knowledge of the millipedes of Czechoslovakia]. *Věstník Královské České Společnosti Nauk*, *Třída II* **1933**: 1–32 (in Czech, with a summary in French).
Lang J. 1954: *Mnohonožky – Diplopoda*. *Fauna ČSR 2* [*Millipedes – Diplopoda*. *Fauna of Czechoslovakia 2*]. Praha: NČSAV, 188 pp. (in Czech, with summaries in Russian and German).
Latzel R. 1884: *Die Myriopoden der Österreichisch-Ungarischen Monarchie. Zweite Hälfte: Die Symphylen, Pauropoden und Diplopoden, nebst Bemerkungen über exotische und fossile Myriopoden-Genera und einem Verzeichnis der gesammelten Myriopoden-Literatur*. Wien: Alfred Hölder, 414 pp.
Mikula J. 2006: *Subteránní společenstva bezobratlých NPP Zbrašovské aragonitové jeskyně a NPR Hůrka u Hranic* [*Subterranean Invertebrate Communities of the Zbrašov Aragonite Caves Reserve and the Hůrka u Hranic Reserve*]. Unpubl. Thesis. Olomouc: Palacký University, Faculty of Science, Department of Ecology and Environmental Science, 58 pp + CD-ROM (in Czech, with an abstract in English).
Mock A., Tajovský K., Žurovcová M., Angyal D. & Kocourek P. 2014: Hungarosoma bokori Verhoeff, 1928 (Diplopoda, Chordeumatida), a tiny and enigmatic millipede: Redescription and new light to its systematics, ecology and biogeography. P.: 58. In: Tuf I. H. & Tajovský K. (eds): *16th International Congress of Myriapodology. Book of Abstracts*. Olomouc: Institute of Soil Biology, BC ASCR & Faculty of Science, Palacký University Olomouc, 122 pp.
Riedel P. 2008: *Chilopoda*, *Diplopoda*, *and Oniscidea in the City.* Unpubl. Thesis. Olomouc: Palacký University, Faculty of Science, Department of Ecology and Environmental Science, 53 pp.
Riedel P., Navrátil M., Tuf I. H. & Tufová J. 2009: Terrestrial isopods (Isopoda: Oniscidea) and millipedes (Diplopoda) of the City of Olomouc (Czech Republic). Pp.: 125–132. In: Tajovský K., Schlaghamerský J. & Pižl V. (eds): *Contributions to Soil Zoology in Central Europe III*. České Budějovice: Institute of Soil Biology, BC ASCR, 191 pp.
Rosický F. 1876: Stonožky země české [Myriapods of the Bohemia]. *Archiv pro Přírodovědné Proskoumání Čech* **3**(4, 27): 1–40 (in Czech).
Skoumalová I. 2010: *Mnohonožky Českého a Moravského krasu* [*Diplopods of the Bohemian and Moravian Karst Areas*]. Unpubl. Thesis. Praha: Charles University, Faculty of Education, Department of Biology and Environmental Studies, 114 pp + xx appendices + 2 atlanti (in Czech, with an abstract in English).
Tajovský K. 2001: Millipedes (Diplopoda) of the Czech Republic. *Myriapodologica Czecho-Slovaca* **1**: 11–24.
Tajovský K. & Mlejnek R. 2007: Nálezy nových druhů troglofilních mnohonožek [Findings of new troglophilous species of millipedes]. *Ochrana Přírody* **62**: 19–20 (in Czech, with a summary in English).
Tajovský K., Mock A. & Papáč V. 2014: The genus Hylebainosoma Verhoeff, 1899 (Diplopoda, Chordeumatida, Haaseidae): redescription of H. tatranum, description of a new troglobiont species and notes to the Hylebainosoma-Romanosoma species group. *Zootaxa* **3764**: 501–523.
Tuf I. H. & Tufová J. 2008: Proposal of ecological classification of centipede, millipede and terrestrial isopod faunas for evaluation of habitat quality in Czech Republic. *Časopis Slezského Muzea v Opavě* (*A*) **57**: 37–44.
Uličný J. 1883: Bericht über bei Brünn gesammelte Myriopoden. *Verhandlungen der Naturforschenden Vereines in Brünn* **22**: 17–21.
Wankel H. 1861: Beiträge zur österreichischen Grottenfauna. *Sitzungsberichte der Akademie der Wissenschaften in Wien*, *Mathematisch-Naturwissenschaftliche Classe* **43**: 251–264.

Acta Soc. Zool. Bohem. **80**: 39–44, 2016
ISSN 1211-376X

Conglobation as a defensive behaviour of pill millipedes (Diplopoda: Glomerida)

Ivan Hadrián Tuf[1)], Lucie Čmielová[1)] & Jan Šipoš[2)]

[1)] Department of Ecology and Environmental Sciences, Faculty of Science, Palacký University, Šlechtitelů 27, CZ–779 00 Olomouc, Czech Republic; e-mail: ivan.tuf@upol.cz
[2)] Department of Biology and Ecology, Faculty of Science, University of Ostrava, Chitussiho 10, CZ–710 00 Slezská Ostrava, Czech Republic

Received 26 November 2014; *accepted 13 August 2015*
Published 12 April 2016

Abstract. Conglobation (rolling-up) is a typical defensive behaviour of pill millipedes (Diplopoda: Glomerida). Reactions of millipedes to a number of stimuli necessary to evoke conglobation and its persistence following three types of treatment were evaluated. The treatments were: touching, squeezing and dropping. Millipedes responded most strongly to being squeezed, but the longest duration of conglobation was recorded after repeated touching. In addition, to the response to the different types of treatment, the response and its persistence increased during an experiment, i.e. from the first to the third treatment.

Key words. Volvation, conglobation, death feigning, tonic immobility, Diplopoda, *Glomeris pustulata*.

INTRODUCTION

Volvation or conglobation is the adoption of a rolled-up posture, which is a typical defensive behaviour of several phylogenetically related groups of animals. Volvation occurs in mammals (armadillos, hedgehogs), mites (Oribatida), insects (cuckoo wasps), and crustaceans (Oniscidea). Among diplopods, volvation is typical of pill millipedes (Glomerida) and giant pill millipedes (Sphaerotheriida). This posture is basically defensive as the animal's legs and other delicate appendages are withdrawn inside the rolled-up body, which is protected by robust tergites and dorsal sheets and/or by spines as in extinct *Amynilyspes* Scudder, 1882 (Hannibal 1984) and hedgehogs. A thick cuticle is necessary not only for passive protection, but as support for strong muscles, which are necessary for maintaining this position in so called tonic immobility. This presents predators with a challenge; how to open the hard globe. Observations on mongooses in captivity and the field revealed that they can overcome this defensive mechanism by throwing millipedes at stones or trees (Eisner & David 1967, Eisner 1968).

The perfect enrolment of pill millipedes is possible because of particular adaptations: short body of subcylindrical form, emarginations in its terga (Hannibal & Feldmann 1981) and appropriate musculature. Associated with these adaptations is slow movement and inability to move laterally (Manton 1954). Upon encountering a predator prey individuals can run or feign death, but not both at the same time. King & Leaich (2006) report a negative relationship between tonic immobility and locomotor activity in a parasitoid wasp, which is similar to the slow movement exhibited by Glomerida that use volvation as their main defence (some Glomerida, but not Sphaerotheriida, also produce a repellent secretion; Shear et al. 2011).

Nevertheless, another possible function of rolling-up may be to minimise water loss by transpiration through the fine cuticle on the legs and ventral surfaces, which has been experimentally

confirmed for pill bugs (Smigel & Gibbs 2008). The aim of this study was to evaluate role of conglobation in a pill millipede defence using different treatments.

MATERIALS AND METHODS

Pill millipedes *Glomeris pustulata* Fabricius, 1781 (Fig. 1a) were collected in April 2011, during an excursion to Hůrka u Hranic National Nature Reserve in Moravia, the Czech Republic. Local forests were damaged by a windstorm in summer 2008 and several gaps were created. Pill millipedes are very abundant under the bark of fallen beech trees in such

Fig. 1. The pill millipede, *Glomeris pustulata* Fabricius, 1781, is frequently found occurring at high densities under bark of fallen beeches: (above) pill millipedes eating faecal pellets of other phloem decomposers, (below) millipedes are abundant in their typical microhabitats.

gaps in forests (Fig. 1b). All millipedes were placed in a large plastic box with leaf litter and pieces of bark and kept at a constant temperature of 18 °C in constant darkness. One day before the start of the experiment, 150 millipedes (ca. 9 mm in size) were placed separately in small plastic boxes with moistened plaster of Paris at the bottom and leaf litter as food and shelter. All millipedes were tested five times on five different days over a period of three weeks; protocol followed previous research on terrestrial isopods (Tuf et al. 2015). Each experiment (one per day) consisted of three treatments, i.e. touching, squeezing and dropping in alternated order, with short breaks (ca. 30 min) between them. Touching was applied as a gentle nudge using the tips of pincers; this treatment was meant to resemble the touch of a small invertebrate predator. Squeezing was applied by holding the pill bug for up to 1 s using soft entomological pincers, which was meant to resemble being held by a bigger (vertebrate) predator. Dropping was applied by holding the pill bugs in pincers and dropping them from a height of 5–10 cm, which was meant to resemble manipulation by an even bigger predator, such as a bird or lizard. The order of these treatments was changed between experiments, i.e. each treatment was used as the first, the second or the third in the sequence, respectively. Each treatment was repeated up to five times and if volvation occurred its duration was measured up to the first sign of the animal resuming activity.

Data on the duration of volvation were analyzed using ANOVA tests and that on the number of stimuli using Pearson's χ^2 tests. Visualisations of results were done in Microsoft Excel programme.

RESULTS

A total of 150 pill millipedes were tested, 97% of which conglobated in reaction to the experimental treatments. We evaluated persistence, i.e. duration, of volvation following each type of treatment (touching, squeezing and dropping) and the sequence of treatment (the first, second or third), respectively (Fig. 2). The longest duration of volvation was recorded following touching (89 s), the shortest following squeezing (61 s) and the length of volvation was affected by the type of stimulus (Anova: $F=6.00$, $p=0.003$, Fig. 2a). The length of volvation was also affected by the order in which the stimuli were applied; there was an increase in the duration of volvation during the experiment from 62 s to 91 s following the third stimulus (Anova: $F=6.24$, $p=0.002$, Fig. 2b).

Another characteristic of the defence behaviour tested was the reactivity of pill millipedes to the order in which the different types of treatments were presented (Fig. 3). Reactivity can be measured in terms of the number of repeats of the same stimulus necessary to induce the millipede to adopt a rolled-up posture. There were significant differences in their reactivity to the different stimuli ($\chi^2=452.91$, $df=8$, $p<0.001$, Fig. 3a), with rolling-up being induced by touching repeated 2.14 times and squeezing only 1.71 times. Also the order in which the stimuli were presented was important in determining millipede reactivity ($\chi^2=31.25$, $df=8$, $p<0.001$, Fig. 3b), with the first stimulus having to be applied 2.10 times and the third stimulus only 1.85 times.

DISCUSSION

We evaluated the defence behaviour of pill millipedes using three types of stimuli and measured the duration of conglobation and number of repetition of each stimulus necessary to evoke volvation. These characteristics of its defence behaviour were associated with the type of treatment and order in which it was presented during the experiment.

Type of treatment

Reactivity and persistence of volvation was affected by the type of treatment. The longest response was evoked by touching; nevertheless a greater number of touching stimuli were needed to induce volvation. In contrast to their reactivity to touching, their reactivity to squeezing was more sensitive (a lower number of stimuli were required to induce conglobation), but the duration of conglobation was the shortest. This can be associated with the biological meaning of the different types of treatments. Touching is not a violent type of treatment and is similar to the random touching of another millipede when crowded. The pill millipede, *G. pustulata*, occurs under bark

at high densities, so random touching of conspecific animals is probably a common event. To react to each random touching by volvation is unnecessary and time consuming. Nevertheless, if touched repeatedly at short intervals, it is similar to being manipulated by a small predator, such as a spider, ground beetle, ant or centipede (Quadros et al. 2012, Tuf et al. 2015). These small invertebrate predators repeatedly attack millipedes or wait until they un-roll; the pill millipede's longer tonic immobility in response to this stimulus is an adaptive response to this threat.

Unlike touching, squeezing is more similar to being manipulated by a larger vertebrate predator and therefore a fewer repeats of this treatment induces rolling-up. Small mammals, birds and lizards, can squeeze and loose their prey while manipulating it and are more likely to swallow the pill millipede whole than wait for it to un-roll. For this reason, it is not advantageous to remain rolled-up for a long time and therefore the duration of volvation was shortest following this stimulus. The association between squeezing and dropping is interesting. Volvation following dropping lasted for longer. If a big predator squeezes and then abandons a millipede for a while

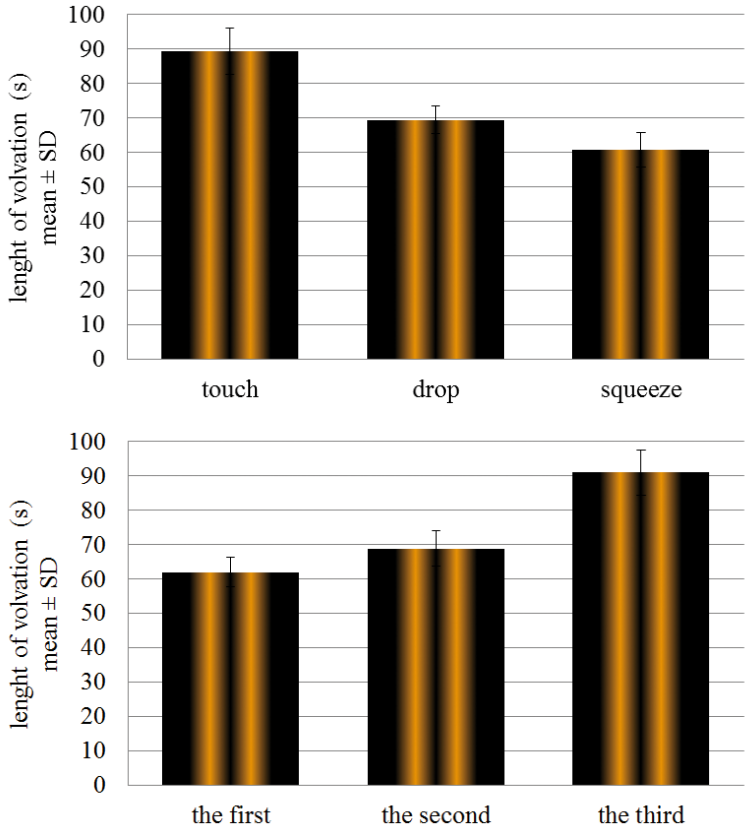


Fig. 2. Duration of the defensive posture of pill millipedes depending on (above) the type of treatment and (below) the order in which the different treatments were presented in each of the experiments.

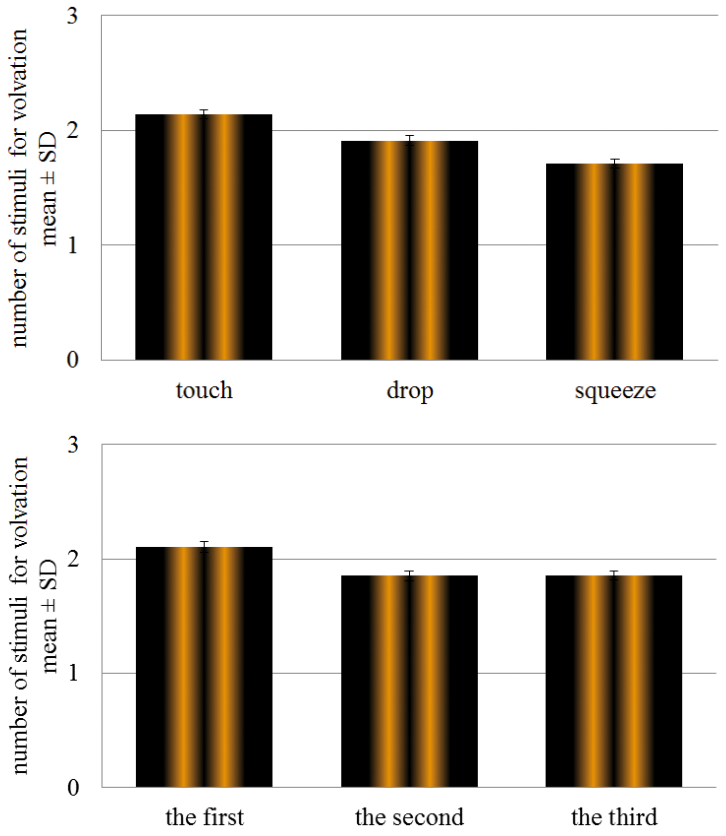


Fig. 3. Reactivity of pill millipedes depending on (a) the type of treatment and (b) the order the order in which the different treatments were presented in each of the experiments.

this possibly indicates that the predator has withdrawn. But if a predator squeezes a millipede and drops it from a height is likely the predator is searching for that millipede, so the longer it remains rolled-up the more likely the predator will give up searching for it.

Order in which the stimuli are presented

To evaluate the effect of the order in which the different treatments were presented, the order was different in the different experiments. In addition, to the type of treatment, it was evident, that both reactivity and persistence of volvation increased during an experiment. Millipedes subjected to repeated "attacks" conglobated more quickly and remained rolled-up for longer.

In addition, the reactivity of millipedes can be affected by its previous behaviour. Srinivasa & Mohanraju (2011) report that feeding millipedes are less likely to adopt a defensive posture than walking or resting millipedes. The greater incidence of pill millipedes responding to the second and third disturbance during the course of an experiment is probably due to their not feeding as a result of experiencing the first disturbance.

CONCLUSION

Pill millipedes conglobated readily in response to several types of stimuli, especially following squeezing (≈ attack by a large predator) and remained rolled-up for longer following touching (≈ manipulation by a small invertebrate predator). The highest reactivity and longest duration of volvation was induced by the third stimulus in the series in each experiment, irrespective what it was, i.e. millipedes became more sensitive to these stimuli during the course of an experiment.

Acknowledgements

This research was partly supported by Internal Grant Agency of Palacký University No. PrF_2014_021 and by European project No. CZ.3.22/1.2.00/12.03445, an Operational Programme for Cross Border Co-operation CZ-PL. The language of the manuscript was kindly checked by Professor Anthony F. G. Dixon (Norwich, UK).

REFERENCES

Eisner T. 1968: Mongoose and millipedes. *Science* **160**(3834): 1367.

Eisner T. & David J. A. 1967: Mongoose throwing and smashing millipedes. *Science* **155**(3762): 577–579.

Hannibal J. 1984: Pill millipedes from the Coal Age. *Field Museum of Natural History Bulletin* **55**(8): 12–16.

Hannibal J. T. & Feldmann R. M. 1981: Systematics and functional morphology of Oniscomorph millipedes (Arthropoda: Diplopoda) from the Carboniferous of North America. *Journal of Paleontology* **55**: 730–746.

King B. H. & Leaich H. R. 2006: Variation in propensity to exhibit thanatosis in Nasonia vitripennis (Hymenoptera: Pteromalidae). *Journal of Insect Behavior* **19**: 241–249.

Manton S. M. 1954: The evolution of Arthropodan locomotory mechanisms. Part 4: The structure, habits and evolution of the Diplopoda. *Journal of the Linnean Society* (*Zoology*) **42**: 299–368.

Quadros A. F., Bugs P. S. & Araujo P. B. 2012: Tonic immobility in terrestrial isopods: intraspecific and interspecific variability. *ZooKeys* **176**: 155–170.

Shear W. A., Jones T. H. & Wesener T. 2011: Glomerin and homoglomerin from the North American pill millipede Onomeris sinuata (Loomis, 1943) (Diplopoda, Pentazonia, Glomeridae). *International Journal of Myriapodology* **4**: 1–10.

Srinivasa Y. B. & Mohanraju J. 2011: To coil, or not to – activity associated ambiguity in defense responses of millipedes. *Journal of Insect Behavior* **24**: 488–496.

Smigel J. T. & Gibbs A. G. 2008: Conglobation in the pill bug, Armadillidium vulgare, as a water conservation mechanism. *Journal of Insect Science* **8**: 1–9.

Tuf I. H., Drábková L. & Šipoš J. 2015: Personality affects defensive behaviour of Porcellio scaber (Isopoda, Oniscidea). *ZooKeys* **515**: 159–171.

Acta Soc. Zool. Bohem. **80**: 45–50, 2016
ISSN 1211-376X

An annotated checklist of the centipedes (Chilopoda) recorded in the Czech Republic

Ivan Hadrián Tuf[1)] & Karel Tajovský[2)]

[1)] Department of Ecology and Environmental Sciences, Faculty of Science, Palacký University, Šlechtitelů 27, CZ–779 00 Olomouc, Czech Republic; e-mail: ivan.tuf@upol.cz
[2)] Biology Centre CAS, Institute of Soil Biology, Na Sádkách 7, CZ–370 05 České Budějovice, Czech Republic

Received 26 June 2015; *accepted 23 October 2015*
Published 12 April 2016

Abstract. This annotated checklist of centipedes includes all the species reported occurring in the Czech Republic up to the end of 2015. Species that were not previously reported in the literature are also listed along with details of these records and the localities. In total, this checklist of centipedes known to occur in the Czech Republic includes 72 species.

Key words. Catalogue, Chilopoda, Geophilomorpha, Lithobiomorpha, Scolopendromorpha, Scutigeromorpha, Czech Republic.

INTRODUCTION

The history of the knowledge of the Czech centipedes goes back to the twenties of the 19th century. The first historical report on centipedes in the Czech Republic is mentioned by von Uechtritz (1820), who recorded *Scutigera coleoptrata* (Linnaeus, 1758) in the Nízký Jeseník Mountains. The first valuable contribution summarising the data for what is now the Czech Republic is in Latzel's (1880) "Die Myriopoden der Österreichisch-Ungarischen Monarchie" and two volumes of Haase's (1880, 1881) "Schlesiens Chilopoden" and Vališ's brief list of Moravian myriapods (Vališ 1904). All these researchers mainly collected material in Moravia, i.e. the eastern part of the Czech Republic.

After the establishment of Czechoslovakia, there was an increase in interest in national faunas, mainly due to Božena Folkmanová. She first produced a monograph on the fauna of centipedes recorded in Bohemia (western part of the Czech Republic), which was published in the late twenties (Folkman 1928, Folkmanová 1928). This monograph and a later updated key for identifying Czechoslovak centipedes led to an increase in the popularity of these invertebrates within the wider community of Czech zoologists. In addition to Folkmanová, other myriapodologists, such as V. Borek, E. Hachler, J. Lang and L. J. Dobroruka published new records (see Tuf & Laška 2005 for review). The revision of the taxonomical status of some centipede species described based on material from this country decreased the total number of species in the national checklist. The increase in faunistic research and monitoring of previously neglected regions of the present Czech Republic since the nineties of the past century resulted in new records and completion of our knowledge of the Czech centipede fauna. The first comprehensive check list of Czech centipedes was published at the beginning of this century (Tajovský 2001). Re-evaluation of the identity of some of the species in the genus *Lithobius* Learch, 1814 described by L. J. Dobroruka from the former Czechoslovakia led to their exclusion and thus a reduction in the number of species known to occur in this country (Tuf et al. 2008).

The lists of species published in the following years (Tuf & Laška 2005, Tuf & Tufová 2008) were brought up to date by including records of another species new to the Czech fauna. The checklist presented is based on published and unpublished data and records, and contains all the species that are known to occur in the Czech Republic.

MATERIALS AND METHODS

The checklist is based on the last published list (Tuf & Tufová 2008) and corrected according to recently presented synonymies (Bonato & Minelli 2014, Tuf & Dányi 2015) and recently recorded species (e.g. Tuf & Kupka 2015). Taxonomy accords with Chilobase (Minelli et al. 2006) and list of geophilomorph centipedes (Bonato & Minelli 2014). New records of centipedes are indicated by the faunistic square code (FSC) for mapping their distribution in the Czech Republic (Buchar 1982).

RESULTS AND DISCUSSION

The following checklist of the centipedes in the Czech Republic based on records in the literature and data recently collected by us contains 72 species. Code superscript numbers at the ends of the species names refer to notes in the following text.

Scutigeromorpha	Scutigeridae	*Scutigera coleoptrata* (Linnaeus, 1758)
Lithobiomorpha	Henicopidae	*Lamyctes emarginatus* Newport, 1844
		Lamyctes africanus (Porath, 1871)[1]
	Lithobiidae	*Eupolybothrus grossipes* (C. L. Koch, 1847)[2]
		Eupolybothrus tridentinus (Fanzago, 1874)
		Harpolithobius anodus (Latzel, 1880)
		Lithobius aeruginosus L. Koch, 1862
		Lithobius agilis L. Koch, 1847
		Lithobius austriacus Verhoeff, 1937
		Lithobius biunguiculatus Loksa, 1947[3]
		Lithobius borealis Meinert, 1868
		Lithobius burzenlandicus Verhoeff, 1934
		Lithobius calcaratus C. L. Koch, 1844
		Lithobius crassipes L. Koch, 1862
		Lithobius curtipes C. L. Koch, 1847
		Lithobius cyrtopus Latzel, 1880
		Lithobius dentatus C. L. Koch, 1844
		Lithobius erythrocephalus C. L. Koch, 1847
		Lithobius forficatus Linnaeus, 1758
		Lithobius lapadensis Verhoeff, 1900
		Lithobius lapidicola Meinert, 1872
		Lithobius latro Meinert, 1872
		Lithobius lucifugus L. Koch, 1862
		Lithobius lusitanus Verhoeff, 1925[4]
		Lithobius luteus Loksa, 1947
		Lithobius macilentus L. Koch, 1862
		Lithobius melanops Newport, 1845
		Lithobius micropodus (Matic, 1980)
		Lithobius microps Meinert, 1868
		Lithobius mutabilis L. Koch, 1862
		Lithobius muticus C. L. Koch, 1847
		Lithobius nodulipes Latzel, 1880
		Lithobius pelidnus Haase, 1880
		Lithobius piceus L. Koch, 1862
		Lithobius punctulatus C. L. Koch, 1847

		Lithobius salicis Verhoeff, 1925[5] *Lithobius schuleri* Verhoeff, 1925 *Lithobius tenebrosus* Meinert, 1872 *Lithobius tricuspis* Meinert, 1872
Scolopendromorpha	Cryptopidae	*Cryptops anomalans* Newport, 1844 *Cryptops hortensis* (Donovan, 1810) *Cryptops parisi* Brölemann, 1920
Geophilomorpha	Dignathodontidae	*Dignathodon microcephalus* (Lucas, 1846) *Henia brevis* (Silvestri, 1896)[6] *Henia illyrica* (Meinert, 1870) *Henia vesuviana* (Newport, 1845)[7]
	Geophilidae	*Clinopodes flavidus* C. L. Koch, 1847 *Geophilus alpinus* Meinert, 1870[8] *Geophilus carpophagus* Leach, 1815 *Geophilus electricus* (Linnaeus, 1758) *Geophilus flavus* (De Geer, 1778) *Geophilus oligopus* (Attems, 1895) *Geophilus osquidatum* Brölemann, 1909 *Geophilus proximus* C. L. Koch, 1847 *Geophilus pygmaeus* Latzel, 1880[9] *Geophilus truncorum* Bergsoe & Meinert, 1866 *Pachymerium ferrugineum* (C. L. Koch, 1835) *Photophilus griseus* Folkmanová, 1928[10] *Polygonarea silvicola* Lawrence, 1955[11] *Stenotaenia linearis* (C. L. Koch, 1835) *Stenotaenia sorrentina* (Attems, 1903)[12]
	Himantariidae	*Haplophilus subterraneus* (Shaw, 1794)[13] *Himantarium gabrielis* (Linneaus, 1767)[14]
	Linotaeniidae	*Strigamia acuminata* (Leach, 1815) *Strigamia crassipes* (C. L. Koch, 1835) *Strigamia pusilla* (Sseliwanoff, 1884)[15] *Strigamia transsilvanica* (Verhoeff, 1928)
	Mecistocephalidae	*Tygarrup javanicus* Attems, 1929[16]
	Schendylidae	*Schendyla carniolensis* Verhoeff, 1902[17] *Schendyla monoeci* Brölemann, 1904 *Schendyla nemorensis* (C. L. Koch, 1837) *Schendyla tyrolensis* (Meinert, 1870) [18]

[1] *Lamyctes africanus* was found recently in Europe (Enghoff et al. 2013), particularly Denmark (outdoors), England and France (indoors). This species (8 females) was found in the Palm greenhouse of the Fairground Flora Olomouc (FSC 6469a), 15 April 2013, leg. I. H. Tuf, M. Maňas & A. Jansová.

[2] *Eupolybothrus grossipes* – its occurrence in the Czech Republic is doubtful, it is only mentioned without precise locality (Southern Moravia) in Folkmanová's key (Folkmanová 1959) and there are no other historical or recent records.

[3] *Lithobius biunguiculatus* was reported for the first time from this country in 2004. In addition to the localities published by V. Laška (2004), there is a new record from Olomouc (FSC 6369d), Central Moravia, of two individuals caught in pitfall traps in 2006 (Navrátil 2007). Four specimens of this species were also collected near the Okrouhlá Natural Monument (NM) in the White Carpathians Protected Landscape Area (PLA) (FSC 6974c), Southeast Moravia, leg. K. Marvanová (Pavelková 2008) in 2006–2007.

[4] *Lithobius lusitanus* is reported only by B. Folkmanová from the Beskydy PLA and by L. J. Dobroruka from the Podyjí National Park (NP) in the fifties and nineties of 20th century (Laška 2004), but its presence was not confirmed by recent investigations (Tajovský 2001, Kula et al. 2011, Kula & Lazorík 2015).

[5] *Lithobius salicis* is reported, like the previous species, only by B. Folkmanová and L. J. Dobroruka (Laška 2004) and not confirmed by the recent intensive investigations of e.g. Podyjí NP (Tajovský 2001), and its presence in the Czech Republic is uncertain.

[6] *Henia brevis* was found for the first time by M. Navrátil (2007) in Olomouc (FSC 6469b); three individuals were heat extracted from soil samples in 2006. This species was also repeatedly collected from soils in apple orchards near Blahotice (FSC 5750d) and Slaný (FSC 5750d), Central Bohemia; a total of 17 individuals over the period 2009–2011, leg. K. Tajovský.

[7] *Henia vesuviana* is recorded in the cities of Jičín (FSC 5558), Eastern Bohemia, and Olomouc (FSC 6469) by P. Riedel in 2006 (Riedel 2008).

[8] *Geophilus alpinus* is a well-known species in the Czech Republic, nevertheless until today it has been repeatedly (cf. Kula & Lazorík 2015) reported under its junior synonym *Geophilus insculptus* Attems, 1895 (Bonato & Minelli 2014).

[9] *Geophilus pygmaeus* is a species reported for the first time by J. Vališ (1902), who collected one female in Boskovice, Central Moravia in March 1901. The second individual was found by M. Navrátil in 2006 in Hodonín, South Moravia, near railway route (FSC 7168b) (Navrátil 2007, Riedel 2008).

[10] *Photophilus griseus* is a mysterious geophilomorph centipede, which was collected by B. Folkmanová who found four specimens in full sun in 1925 at St. John rapids (Svatojánské proudy), which is today located at the Štěchovice Reservoir (Vltava River), Central Bohemia. Folkmanová tried to find this species again for at least another 25 years, but was unsuccessful (Folkmanová 1952). This species was incorrectly reported from Poland (cf. Kaczmarek 1963, 1980). Its validity is uncertain.

[11] *Polygonarea silvicola* – based on Czech record this species was reported for the first time also for the whole of Europe (Dányi & Tuf 2016). One female was found by I. H. Tuf in the Palm greenhouse of the Fairground Flora Olomouc (FSC 6469a), 15 April 2013. The species is originally known from South Africa.

[12] *Stenotaenia sorrentina* is the valid name for species, which is reported under its junior synonym *Clinopodes linearis abbreviatus* (Verhoeff, 1925) (see Bonato & Minelli 2014) from Bílý kříž (FSC 6577a) and Kněhyně (FSC 6575b) in Beskydy PLA by Wytwer and Tajovský (2005).

[13] *Haplophilus subterraneus* is mentioned in a previous checklist under the name *Stigmatogaster subterranea* (Shaw, 1789). This species was recorded by K. Tajovský in the suburban park in České Budějovice (FSC 7052b); information was notified by Lindner (2007).

[14] *Himantarium gabrielis* was found at the car park near Lednice castle (FSC 7166d), South Moravia, 29 April 2012, 1 specimen, leg. R. Vlk.

[15] *Strigamia pusilla* – three individuals of this species were reported recently from the Beskydy PLA (6476d) by J. Kupka (Tuf & Kupka 2015).

[16] *Tygarrup javanicus* occurs in greenhouses in Great Britain, Germany and Austria (Stoev et al. 2010, Decker et al. 2014), one female of this species was found by D. Říhová & J. H. Ponert in mountainous part of the Fata Morgana greenhouse in Prague (FSC 5852c), 12 January 2012.

[17] *Schendyla carniolensis* was found in the White Carpathians PLA, Southeast Moravia: the Ve Vlčí Nature Reserve (FSC 7073c), 18 October 2008, leg. I. H. Tuf; Žítková (FSC 7073a), 12 November 2009, leg. K. Tajovský.

[18] *Schendyla tyrolensis* is mentioned in previous checklists under its synonym *Schendyla montana* Attems, 1895. In addition to the first (Tajovský 1998) and repeated records from North Bohemia, it was collected in soils from apple orchards near Blahotice (FSC 5750d), Slaný (FSC 5750d), Knovíz (FSC 5750d) and in a natural forest steppe habitat at Vinařická hora NM (FSC 5850ab), all in Central Bohemia; in total 18 individuals were collected during the period 2009–2011, leg. K. Tajovský.

Unlike previous versions of the checklist of Czech centipedes (Tajovský 2001, Tuf & Laška 2005, Tuf & Tufová 2008), the species *Folkmanovius paralellus* Dobroruka, 1957, is not listed. Its synonymy is described recently (Tuf & Dányi 2015); *F. paralellus* is a junior synonym of *Clinopodes flavidus.*

Recent records of new centipedes occurring in the Czech Republic indicate that greenhouses are likely to harbour more species of centipedes. In addition to these and other artificial habitats in urban and suburban landscapes, more attention should also be focused on natural biotopes, especially in eastern and southern districts, which might host other species of Carpathian or Pannonian origin.

Acknowledgements

This research was supported by the Internal Grant Agency of the Palacký University, Olomouc, No. PrF_2015_008.

REFERENCES

Bonato L. & Minelli A. 2014: Chilopoda Geophilomorpha of Europe: a revised list of species, with taxonomic and nomenclatorial notes. *Zootaxa* **3770**: 1–136.

Buchar J. 1982: Způsob publikace lokalit živočichů z území Československa [A method of publication of animal localities from the territory of Czechoslovakia]. *Věstník Československé Společnosti Zoologické* **46**: 317–318 (in Czech).

Dányi L. & Tuf I. H. 2016: Out of Africa: The first introduced African geophilomorph centipede record from an European greenhouse (Chilopoda: Geophilidae). *Zootaxa* **4067**: 585–588.

Decker P., Reip H. & Voigtländer K. 2014: Millipedes and centipedes in German greenhouses (Myriapoda: Diplopoda, Chilopoda). *Biodiversity Data Journal* **2**: e1066. doi: 10.3897/BDJ.2.e1066.

Enghoff H., Akkari N. & Pedersen J. 2013: Aliquid novi ex Africa? Lamyctes africanus (Porath, 1871) found in Europe (Chilopoda: Lithobiomorpha: Henicopidae). *Journal of Natural History* **47**: 2071–2094.

Folkman B. 1928: Les Chilopodes de Tchécoslovaquie. 1 Partie. Les Chilopode des Bohême. *Bulletin International* (*Academie Tchéque des Sciences*), *Résumés des Travaux Présentés*, *Classe des Sciences Mathématiques*, *Naturelles et de la Médicine* **29**: 1–75.

Folkmanová B. 1928: *Chilopoda Republiky Československé. Díl 1. Chilopoda Čech*. [*Chilopoda of Czechoslovakia. Part 1: Chilopoda of Bohemia.*] Praha: Nakladatelství Československé akademie věd a umění, 132 pp + 4 tabs. (in Czech).

Folkmanová B. 1952: O některých zajímavých formách podřádu Geophilomorpha z Moravy a Slezska [On some interesting forms of the suborder Geophilomorpha from Moravia and Silesia]. *Přírodovědný Sborník Ostravského Kraje* **13**: 179–192 (in Czech, with a summary in French).

Folkmanová B. 1959: Stonožky – Chilopoda [Centipedes – Chilopoda]. Pp.: 49–66. In: Kratochvíl J. (ed.): *Klíč zvířeny ČSR III* [*Identification Key to the Fauna of Czechoslovakia III*]. Praha: Nakladatelství Československé akademie věd, 869 pp (in Czech).

Haase E. 1880: *Schlesiens Chilopoden. I. Chilopoda anamorpha*. Breslau: Inaugural-Dissertation, 44 pp.

Haase E. 1881: Schlesiens Chilopoden. II. Chilopoda epimorpha. *Zeitschrift für Entomologie*, *Breslau*, *Neue Folge* **8**: 66–92.

Kaczmarek J. 1980: *Pareczniki Chilopoda. Katalog Fauny Polski, 14, 4* [*Centipedes Chilopoda. Catalogus Faunae Poloniae, 14, 4*]. Warszawa: Państwowe Wydawnictvo Naukowe, 44 pp (in Polish).

Kaczmarek W. 1963: An analysis of interspecific competition in communities of the soil macrofauna of some habitats in the Kampinos National Park. *Ekologia Polska*, *Series A* **11**: 421–483.

Kula E. & Lazorík M. 2015: Comparison of Myriapoda in beech and spruce forests. *Journal of Forest Science* **61**: 306–314.

Kula E., Lazorík M. & Tuf I. H. 2011: Contribution to the knowledge of centipedes and terrestrial isopods of the Moravian-Silesian Beskids. *Acta Musei Beskidensis* **3**: 55–63.

Laška V. 2004: *Atlas rozšíření stonožek* (*Chilopoda*) *České republiky* [*Atlas of Distribution of Centipedes* (*Chilopoda*) *of the Czech Republic*]. Unpubl. Thesis. Olomouc: Palacký University, Faculty of Science, Department of Ecology and Environmental Science, 87 pp (in Czech).

Latzel R. 1880: *Die Myriopoden der Österreichisch-Ungarischen Monarchie. Erste Hälfte: Die Chilopoden*. Wien: A. Hölder, 228 pp.

Lindner E. N. 2007: Einige Anmerkungen zum Vorkommen von Stigmatogaster subterraneus (Shaw, 1789) und Henia vesuviana (Newport, 1845) (Chilopoda: Geophilida) in Deutschland sowie Überblick über deren Verbreitung in Europa. *Schubartiana* **2**: 49–56.

Minelli A., Bonato L. & Dioguardi R. (eds) 2006: *Chilobase*: *A Web Resource for Chilopoda Taxonomy*. Publicly searchable at http://chilobase.bio.unipd.it

Navrátil M. 2007: *Stonožky*, *mnohonožky a suchozemští stejnonožci ve městě* (*Olomouc*, *Hodonín*). [*Centipedes*, *Millipedes and Terrestric Isopods in a City* (*Olomouc*, *Hodonín*)]. Unpubl. Thesis. Olomouc: Palacký University, Faculty of Science, Department of Ecology and Environmental Science, 79 pp + 9 appendices + CD-ROM (in Czech, with an abstract in English).

Pavelková K. 2008: *Společenstva stonožek* (*Chilopoda*) *vybraných karpatských lokalit* [*Communities of Centipedes* (*Chilopoda*) *at Several Carpathian Localities*]. Unpubl. Thesis. Olomouc: Palacký University, Faculty of Science, Department of Ecology and Environmental Science, 55 pp + 2 appendices (in Czech, with an abstract in English).

Riedel P. 2008: *Chilopoda*, *Diplopoda*, *and Oniscidea in the City.* Unpubl. Thesis. Olomouc: Palacký University, Faculty of Science, Department of Ecology and Environmental Science, 53 pp.

Stoev P., Zapparoli M., Golovatch S., Enghoff H., Akkari N. & Barber A. 2010: Myriapods (Myriapoda). Chapter 7.2. Pp.: 97–130. In: Roques A., Kenis M., Lees D., Lopez-Vaamonde C., Rabitsch W., Rasplus J.-Y. & Roy D. (eds): *Alien Terrestrial Arthropods of Europe*. *BioRisk* **4**: 1–1028.

Tajovský K. 1998: Terrestrial arthropods (Oniscidea, Diplopoda, Chilopoda) of the Labské pískovce Protected Landscape Area (North Bohemia, Czech Republic). Pp.: 235–242. In: Pižl V. & Tajovský K. (eds): *Soil Zoological Problems*

in Central Europe. Proceedings of the 4th Central European Workshop on Soil Zoology. České Budějovice: Institute of Soil Biology, 283 pp.

Tajovský K. 2001: Současný stav poznání fauny mnohonožek (Diplopoda), stonožek (Chilopoda) a suchozemských stejnonožců (Oniscidea) v Národním parku Podyjí [Present state of the knowledge of millipedes, centipedes and terrestrial isopods in the Podyjí National Park]. *Thayensia* **4**: 161–167 (in Czech, with an abstract in English).

Tuf I. H. & Dányi L. 2015: True identity of Folkmanovius paralellus Dobroruka (Chilopoda: Geophilomorpha: Geophilidae). *Zootaxa* **4058**: 444–450.

Tuf I. H. & Kupka J. 2015: The first record of Strigamia pusilla from the Czech Republic (Chilopoda: Geophilomorpha). *Acta Carpathica Occidentalis* **6**: 108–110.

Tuf I. H. & Laška V. 2005: Present knowledge on centipedes in the Czech Republic: a zoogeographic analysis and bibliography 1820–2003. *Peckiana* **4**: 143–161.

Tuf I. H. & Tufová J. 2008: Proposal of ecological classification of centipede, millipede and terrestrial isopod faunas for evaluation of habitat quality in Czech Republic. *Časopis Slezského Muzea v Opavě* (*A*) **57**: 37–44.

von Uechtritze M. F. S. 1820: *Kleine Reisen eines Naturfoches*. Breslau: J. F. Körn und Ältern, 354 pp.

Vališ J. 1902: Příspěvky k poznání moravské myriopodofauny (stonožky) [Contributions to the knowledge of the Moravian myriapod fauna]. *Časopis Vlasteneckého Spolku Museálního v Olomouci* **19**: 20–27 (in Czech).

Vališ J. 1904: Předběžný přehled dosud z Moravy známých Myriopodů [Preliminary review of up-to-now known myriapods from Moravia]. *Věstník Královské České Společnosti Nauk*, *Třída Mathematicko–Přírodovědná* **28**: 1–12 (in Czech).

Wytwer J. & Tajovský K. 2005: Centipedes in the spruce forests of the Moravskoslezské Beskydy Mountains, Czech Republic. Pp.: 211–215. In: Tajovský K., Schlaghamerský J. & Pižl V. (eds): *Contributions to Soil Zoology in Central Europe I.* České Budějovice: Institute of Soil Biology AS CR, 221 pp.

Acta Soc. Zool. Bohem. **80**: 51–85, 2016
ISSN 1211-376X

The present knowledge of the Symphyla and Pauropoda (Myriapoda) in Germany – an annotated checklist

Karin Voigtländer[1)], Peter Decker[1)], Ulrich Burkhardt[1)] & Jörg Spelda[2)]

[1)] Senckenberg Museum of Natural History Görlitz, Am Museum 1, D–02826 Görlitz, Germany;
e-mail: karin.voigtlaender@senckenberg.de
[2)] Bavarian State Collection of Zoology, Münchhausenstraße 21, D–81247 Munich, Germany

Received 30 October 2014; *accepted 20 February 2015*
Published 12 April 2016

Abstract. Symphyla and Pauropoda are seriously neglected classes of Myriapoda worldwide, with sparse information on ecology and distribution on species level available. The few records of these taxa are scattered in literature, and many new species remain to be discovered even in Europe. For the first time a comprehensive checklist is provided for the Symphyla and Pauropoda of Germany based on a literature review and database and collection queries. Information on distribution and ecology for both taxa so far available is given. Currently 18 taxa of Symphyla and 36 taxa of Pauropoda are known for Germany. New species records from museum collections and new investigations are given, most of these are from Baden-Württemberg, Bavaria, Hesse, North Rhine-Westphalia, Rhineland-Palatinate, sampled during the last decades. *Decapauropus broelemanni* (Remy, 1935) and *Acopauropus ornatus* (Latzel, 1884) are recorded for Germany for the first time. *Trachypauropus cordatus* (Scheller, 1974) is confirmed for Germany from nine localities.

Key words. Distribution, ecology, species list, catalogue, Arthropoda, Myriapoda, Germany, Europe.

INTRODUCTION

The four classes of Myriapoda are very different in their status of taxonomical and ecological investigation. Compared to vast numbers of studies dealing with Chilopoda and Diplopoda, Pauropoda and Symphyla are mostly neglected in ecofaunistical studies, as they contain generally very small species and are difficult to identify. Apart from a few exceptions (Foddai et al. 1995, Gisin 1947, 1949, Rusek 2001a, b, Scheller 1954, 1990), complete checklists for these two groups are lacking for most countries. For Germany the last overview dates back 50 years (Schubart 1964). Together with Diplopoda and Chilopoda, earlier knowledge of Pauropoda (six species) and Symphyla (four species) known so far for Germany was summarised by Verhoeff (1934). The first note on symphylans from Germany was given by Latzel (1895), who reported *Scolopendrella immaculata* (Newport, 1845) and *S. notacantha* Gervais, 1844 from the surroundings of Hamburg. Haase (1884, 1885) recorded the first pauropod species *Stylopauropus pedunculatus* (Lubbock, 1867) from Silesia, which at that time belonged to Germany. Later authors (such as Hansen 1902, Büttner 1926, Griepenburg 1932, 1936) also provided records of pauropods and symphylans. Remy (1936a) in the first extensive survey of Germany added several new records for Pauropoda, so the number of taxa increased to 15.

Since the beginning of the 1960s a somewhat more thorough sampling was initiated mainly by Scheller, Hüther, Dunger and later also by Spelda. A comparatively high number of records of Symphyla and Pauropoda exists from Southwestern Germany (Baden-Württemberg) due to the sampling done by Remy, Scheller and Spelda. While Hüther focused especially on North Rhine-Westphalia and Rhineland-Palatinate, the material brought together by Dunger and others mostly came from Saxony. A number of other authors provided some single records.

Here for the first time a comprehensive checklist for the Symphyla and Pauropoda of Germany is provided, based on a literature review and database and collection queries. Information on habitats and ecology is given for each species including also information from other European countries.

We hope this review will be the basis for more extensive studies on these neglected myriapods in the future.

MATERIALS AND METHODS

The present investigation is based on a comprehensive review of the literature available for Germany. These data are available online in the Global Biodiversity Information Facility (GBIF, http://www.gbif.org, Edwards et al. 2000) and in the Edaphobase data warehouse on soil zoology (http://www.edaphobase.org, Burkhardt et al. 2014).

Additionally material from recent investigations, as well as material from the collections of the Senckenberg Museum of Natural History Görlitz (SMNG), Senckenberg Museum Frankfurt (SMF) collected by A. Allspach, Zoologische Staatssammlung München (ZSM) and the private collection of Jörg Spelda (JSC) (partly listed in Spelda 2005) was studied. Also additional information on the published records from Dunger, deposited in the SMNG, is provided.

The classification of pauropods follows Scheller (1977a, 2008). In addition to the original descriptions we used the following literature for species identification: Edwards (1959a, b), Hasenhütl (1986), and Scheller (1974a, 1976, 1978a).

Abbreviations in the text: A. Allspach (AA), U. Burkhardt (UB), P. Decker (PD), W. Dunger (WD), J. Spelda (JS) K. Voigtländer (KV), Landesamt für Umwelt (LFU), for specimens means leg pairs (L[number]), adult (ad.), individual (ind.) and juvenile (juv.).

Focus-stacked montage images were taken with a Leica® DMS5500B microscope and DFC295 camera (SMNG) and a Leica® SM-LUX microscope with incident illumination at ZSM. HeliconFocus or Leica® Application Suite 3.8 was used for focus-stacking of up to 85 images. Maps were created using ArcMap version 10.0 (ESRI Kranzberg, Germany).

RESULTS

Currently the checklist includes 18 taxa of Symphyla and 36 taxa of Pauropoda for Germany. In Pauropoda 32 valid species from ten genera and five families and in Symphyla 18 species from six genera and two families are known (Table 1). Four species of Pauropoda, *Fagepauropus breviseta*, *Decapauropus cursor*, *D. trichosphaera*, and *D. unicus*, all listed by Hüther (1982) are currently regarded as nomina nuda due to lack of species description and type material.

Table 1. Symphyla and Pauropoda from German Federal States. Abbreviations: L – record from literature, X – new record, F – first record, G – only in greenhouses, ? – imprecise record. BB – Brandenburg, BE – Berlin, BW – Baden-Württemberg, BY – Bavaria, HB – Bremen, HE – Hesse, HH – Hamburg, MP – Mecklenburg-Western Pommerania, NI – Lower Saxony, NW – North Rhine-Westphalia, RP – Rhineland Palatinate, SH – Schleswig-Holstein, SL – Saarland, SN – Saxony, ST – Saxony-Anhalt, TH – Thuringia

	BW	BY	BE	BB	HB	HH	HE	NI	MP	NW	RP	SL	SN	ST	SH	TH
Class Pauropoda																
Family Pauropodidae																
Allopauropus danicus (Hansen, 1902)	LX							L		LX	L	L	L			
Decapauropus aristatus (Remy, 1936)											L					
Decapauropus barcinonensis (Remy, 1933)	L									L	L					
Decapauropus broelemanni (Remy, 1935)	F															
Decapauropus cuenoti Remy, 1931	LX									L	L		LX			
Decapauropus distinctus (Bagnall, 1936)	LX															
Decapauropus doryphorus (Remy, 1936)												L				
Decapauropus gracilis (Hansen, 1902)	LX	X	L	X		L	LX			L	L	L	LX			X
Decapauropus helophorus (Remy, 1936)		L									L					
Decapauropus helveticus (Hansen, 1902)	LX	LX									L					
Decapauropus hessei (Remy, 1935)	L															
Decapauropus kocheri (Remy, 1954)												L				

Table 1. (continued)

	BW	BY	BE	BB	HB	HH	HE	NI	MP	NW	RP	SL	SN	ST	SH	TH
Decapauropus meridianus (Remy, 1941)	L															
Decapauropus multiplex (Remy, 1936)	LX												L			
Decapauropus tenellus (Scheller, 1971)	L						X									
Decapauropus thalassophilus (Remy, 1935)											L	L				
Decapauropus viticolus Hüther, 1975											L					
Decapauropus vulgaris (Hansen, 1902)	LX	LX	L				X		X	LX	L		L			
Pauropus bagnalli Remy, 1935	L															
Pauropus furcifer Silvestri, 1902	L	X					X									X
Pauropus huxleyi Lubbock, 1867	LX	L				L	L			L						
Pauropus lanceolatus Remy, 1937	LX	X				L	L	L			L					
Stylopauropus pedunculatus (Lubbock, 1867)	LX	LX					X			LX	LX	L	LX	L		
Stylopauropus pubescens Hansen, 1902	LX	L					LX				L					
Scleropauropus lyrifer Remy, 1936	L															
Family Polypauropodidae																
Polypauropus duboscqi Remy,1932												L				
Family Amphipauropodidae																
Amphipauropus rhenanus (Hüther, 1971)	(L)										L					
Family Brachypauropodidae																
Brachypauropus hamiger Latzel, 1884	L	L											X			
Brachypauropus strebeli Hüther, 1971											L					
Family Eurypauropodidae																
Trachypauropus cordatus (Scheller, 1974)		F					F			LF						
Acopauropus asper (Scheller, 1974)							L									
Acopauropus ornatus (Latzel 1884)		F														
Decapauropus cursor Hüther, 1982											L					
Decapauropus trichosphaera Hüther, 1982											L					
Decapauropus unicus Hüther 1982											L					
Fagepauropus breviseta Hüther, 1982											L					
Sum of taxa	21	12	2	1	0	3	10	2	1	18	15/19	7	7	1	0	2
Class Symphyla																
Family Scolopendrellidae																
Symphylella elongata Scheller, 1952	LX		L							X						
Symphylella isabellae (Grassi, 1886)	LX	L					X	L		X			LX			
Symphylella major Scheller, 1961	L															
Symphylella vulgaris (Hansen, 1903)	LX	LX	L	L			LX			L	L	L	LX			
Scolopendrellopsis arvernorum (Ribaut, 1931)	L	X									L					
Scolopendrellopsis subnuda (Hansen, 1903)	LX	LX	L				LX		X	LX	L	L	LX			L
Scolopendrella notacantha Gervais, 1839	LX	LX				L				L	L					L
Geophilella pyrenaica Ribaut, 1913	L									L	L					
Family Scutigerellidae																
Hanseniella nivea (Scopoli, 1763)													LX			
Hanseniella oligomacrochaeta Scheller, 2002			G													
Hanseniella orientalis (Hansen, 1903)			G													
Scutigerella causeyae Michelbacher, 1942	LX	LX	L				X			LX	L		X			
Scutigerella immaculata (Newport, 1845)	L	L	L	L		L	L	L	L	L	L		L		L	L
Scutigerella linsleyi Michelbacher, 1942																
Scutigerella nodicercus Michelbacher, 1942	LX	LX									L					
Scutigerella palmonii Michelbacher, 1942	L										L					
Scutigerella remyi Juberthie-Jupeau, 1963		L								L	L					
Scutigerella verhoeffi Michelbacher, 1942	?	?														
Sum of taxa	12	9	7	2	0	2	5	2	2	9	10	2	6	0	1	3

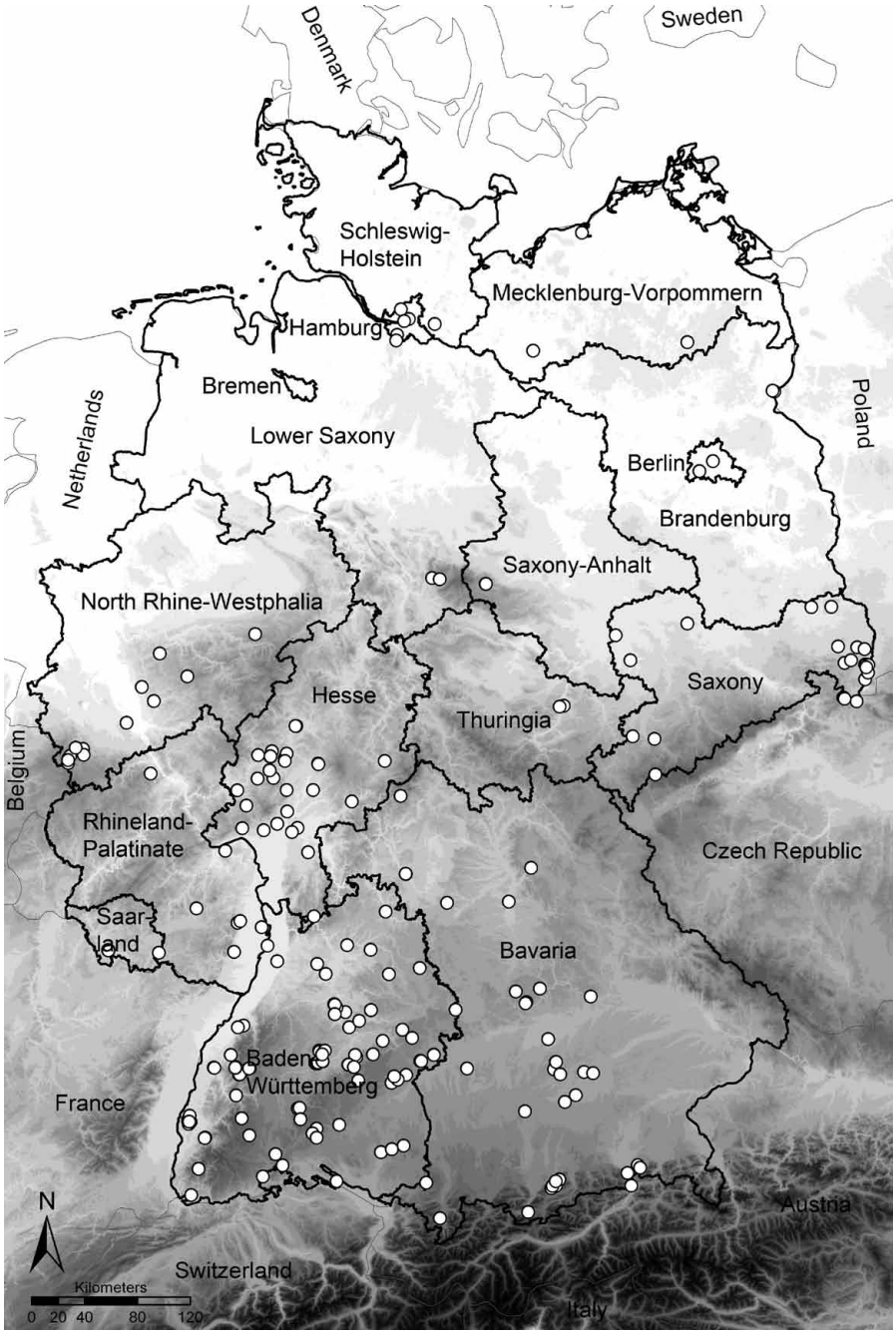


Fig. 1. Record sites of Symphyla and Pauropoda in Germany.

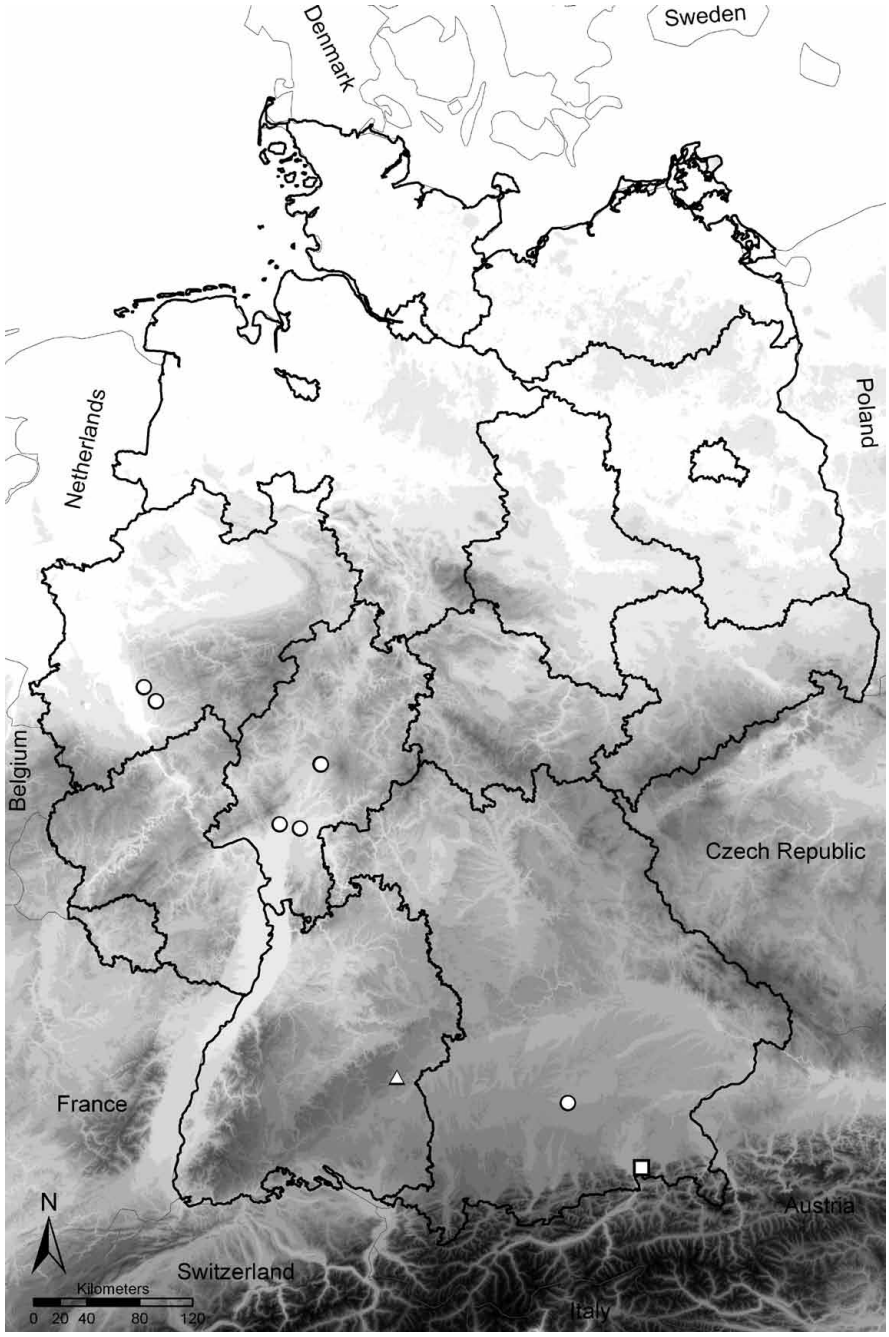


Fig. 2. Records of *Decapauropus broelemanni* (Remy, 1935) (triangle), *Trachypauropus cordatus* (Scheller 1974) (circle) and *Acopauropus ornatus* (Latzel, 1884) (square) in Germany.

Records from about 100 localities could be extracted from literature.

In total about 150 localities for Pauropoda and Symphyla are known for Germany (Fig. 1).

Decapauropus broelemanni (Remy, 1935) and *Acopauropus ornatus* (Latzel, 1844) are recorded here for the first time for Germany, the former from one locality in Baden-Württemberg (Fig. 2), and the latter from the Bavarian Alps (Fig. 2). *Trachypauropus cordatus* (Scheller, 1974), until now known for Germany based merely on a doubtful record (cf.) from Hüther & Kinkler (2013), is newly confirmed for Germany from nine localities in Bavaria, Hesse and North Rhine-Westphalia (Fig. 2).

ANNOTATED CHECKLIST

Class Pauropoda

Family Pauropodidae

Allopauropus danicus (Hansen, 1902)

Previous Records. Between Rhine and Saar, surroundings of Bochum and Braunschweig [general information on collection sites for all species treated in this publication], 1955–1961 (Hüther 1974). **Baden-Württemberg**: Triberg im Schwarzwald, 01/02 June 1936 (Remy 1936a); Endingen am Kaiserstuhl, Katharinaberg, 25 April 1961 (Scheller 1962); Tübingen, Bebenhausen, spruce forest/beech forest, 1996 (Krauß et al. 1998, JSC). **Lower Saxony**: Bad Grund, Grube "Hülfe Gottes", cave, 1936 (Mühlmann 1942). **North Rhine-Westphalia**: Leverkusen, Gronenborn, NSG Gronenborner Teiche, 2005–2011 (Hüther & Kinkler 2013). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982). **Saarland**: Wadgassen, mine heap, *Robinia* afforestation, 1975–1976 (Guttmann 1979). **Saxony**: Görlitz, Berzdorf, brown coal open-cast mine dump with deciduous afforestation three year-old, 12 June 1962, leg. W. Dunger, det. J. Chalupský, 1 ind., (Dunger 1967). [cf.] ibid., 1962, 2 L8; Görlitz, Kiesdorf, floodplain forest, 51.0391° N, 14.883° E, soil cores, 0–5 cm soil depth, 5 November 1962, leg. & det. WD (SMNG, Dunger 1967) 2 L8.

New Records. **Baden-Württemberg**: Vöhrenbach, Linach-Stausee, meadow, 48.0151° N, 8.3113° E, 16 April 1993, flotation process, leg. & det. JS (JSC) 1 juv. **North Rhine-Westphalia**: Langerscheid, spruce forest, leaf litter, 50.52131° N, 6.34056° E, 7 May 2014, leg. SMNG, det. UB (SMNG) 2 L9; Dedenborn, spruce forest, leaf litter, 50.55002° N, 6.34147° E, 7 May 2014, leg. SMNG, det. UB (SMNG) 2 L9; Dedenborn, spruce forest, 50.55002° N, 6.34147° E, 7 May 2014, soil core, 0–5 cm, leg. SMNG, det. UB (SMNG) 1 L8, 1 L9; Schlitterley, oak forest, 50.62028° N, 6.49382° E, 7 May 2014, leg. SMNG, det. UB (SMNG) 1 L9.

Allopauropus danicus is recorded from all continents (subcosmopolitan, Scheller 1982) and very different biotopes. According to Hüther & Kinkler (2013) the species prefers coniferous woodland, where it can be found especially in dead wood affected by red ring-rot. Also Krauß et al. (1998), Scheller (1976, Switzerland), Scheller (1977a, Greece) and Dizdarević (1977, Bosnia and Herzegovina), found this species only in spruce forests and in an Abieti-Picetum. Occurrences in oak forest, beech woods and floodplains are also known (Dizdarević 1971, Dinaric Alps; Scheller 1976, Switzerland; Scheller 1977a, Greece). Rarely *A. danicus* occurs on open land with sparse vegetation (Hüther 1982, Guttmann 1979, both Germany). At Banyuls-sur-Mer, France, Remy (1936b) found the species between leaves lying under the sand at places wetted by spindrift. Records from caves (Remy 1939) as well as from hothouses (Scheller 1976, Switzerland) exist. It was found in soil (especially in loam), under stones, in leaf litter and dead wood (Chalupský 1967, Scheller 1976, 1977a, Dizdarević 1971, 1977, Hüther 1974).

Because of its worldwide distribution and broad and habitat spectrum, Hüther (1982) and Hüther and Kinkler (2013) regard *A. danicus* as a species complex.

Decapauropus aristatus (Remy, 1936)

Record. **Rhineland-Palatinate**: [cf.] Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

This species is widespread in Western and South East Europe. For Germany, the first and only record comes from Hüther 1982 (as *A*. cf. *aristatus*) from a dry deciduous forest dominated by beech, oak and hornbeam. Scheller (1976, 1977a) found this species at the base of steep rocks (Greece) and in a heap of compost in the garden of the National History Museum in Geneve (Switzerland).

Decapauropus barcinonensis (Remy, 1933)

Records. **Baden-Württemberg**: Schelingen, Badberg, south slope, 23 April 1961 (Scheller 1962). **North Rhine-Westphalia**: Leverkusen, Gronenborn, NSG Gronenborner Teiche, 2005–2011 (Hüther & Kinkler 2013). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

This species is widespread in Western Europe and seems to be very eurytopic. It lives in open lands (lush but also dry meadows) as well as in forests and parks under stones, in humus and in leaf litter (e.g. Scheller 1973, Hüther 1982, Remy & Balland 1958, Remy 1941, Loksa 1966, Hüther & Kinkler 2013). Records from caves are also known (Remy 1961a). Even in the drift line at the seashore the species could be found under stones (Remy 1936b).

Decapauropus broelemanni (Remy, 1935)
(Fig. 2)

First record. **Baden-Württemberg**: Blaubeuren, Blautopf, 48.416° N, 9.7859° E, 14 August 2013, hand sampling, leg. & det. JS (ZSM) 1 ♀.

This species is widely distributed in Europe and also known from North Africa and Canada (Andersson et al. 2005). It is found in arable land in Great Britain (Edwards et al. 1967, Remy 1961c), in a birch grove, in *Rhododendron* heaths and a lush pasture in Andorra and Spain (Scheller 1973) as well as in forests (Remy 1938), The highest record comes from 2200 m a. s. l. (Scheller 1973). The species was often found under stones. The German record is from a steep slope on calcareous soil in a karstic area with mixed, mainly deciduous beech forest.

Decapauropus cuenoti Remy, 1931

Previous Records. Between Rhine and Saar, surroundings of Bochum and Braunschweig [general information on collection sites for all species treated in this publication], 1955–1961 (Hüther 1974); **Baden-Württemberg**: Bad Griesbach im Schwarzwald, 24 February 1936, 28 August 1936 (Remy 1936a); Baden-Baden, 6 June 1937 (Remy 1938); Tübingen, Bebenhausen, spruce forest, after windthrows, not cleared, 1996 (Krauß et al. 1998, JSC); Tübingen, Bebenhausen, spruce forest, after windthrows, cleared, newly planted deciduous trees, 1996 (Krauß et al. 1998, JSC); Bad Waldsee, spruce forest, after windthrows, not cleared, 1996 (Krauß et al. 1998, JSC); Tübingen, Bebenhausen, spruce forest/beech forest, 1996 (Krauß et al. 1998, JSC); Freudenstadt, Kniebis, 24 February 1936 (Remy 1936a); Offenburg, 1 June 1936 (Remy 1936a); Schelingen, beech forest, 23 April 1961 (Scheller 1962); Schelingen, Badberg, 23 April 1961 (Scheller 1962); Vogelsang, deciduous forest, 23 April 1961 (Scheller 1962); Triberg im Schwarzwald, 1–2 June 1936 (Remy 1936a); Ulm, Langenau, spruce forest, 1996 (Krauß et al. 1998, JSC). **North Rhine-Westphalia**: Leverkusen, Gronenborn, NSG Gronenborner Teiche, 2005–2011 (Hüther & Kinkler 2013). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982). **Saxony**: Görlitz, Berzdorf-Tauchritz, Langteichhalde, brown coal open-cast mine dump with deciduous afforestations 10 year-old, 51.065° N, 14.932° E, 30 March 1962, soil core, 0–5 cm soil depth, leg. WD, det. J. Chalupský (SMNG, Dunger 1966, 1968) 1 ind.; Görlitz, Berzdorf-Tauchritz, Teichhalde, brown coal open-cast mine dump with deciduous afforestations six year-old, 51.065° N, 14.939° E, 7 May 1965, soil core, 5–10 cm soil depth, leg. & det. WD (SMNG, Dunger 1966, 1968) 1 ind.; Görlitz, Kiesdorf, floodplain forest, 51.0391° N, 14.883° E, soil cores, 0–5 and 5–10 cm soil depth, leg. & det. WD (SMNG, Dunger 1966, 1968) 26 June 1962, 1 L10; 21 May 1962, 1 L6; 16 July 1962, 1 L6 (det. J. Chalupský), 10 September 1962, 2 L8.

New Records. **Baden-Württemberg**: Ulm, Herrlingen, Kiesental, 48.4247° N, 9.9082° E, 6 May 1997, substrate sampling, leg. & det. JS (JSC) 5 ♀; Neidlingen, Reußenstein, 48.5662° N, 9.5704° E , 01 May 1997, substrate sampling, leg. & det.

JS (JSC) 2 ♀; Neuffen, Bäuerloch, 48.5501° N, 9.4001° E, 28 June 1997, substrate sampling, leg. & det. JS (JSC) 1 ♀, 1 juv.; Nordheim, 3 km NE Neipperg, 49.1162° N, 9.0863° E, 19 April 1997, substrate sampling, leg. & det. JS (JSC) 1 ♂, 3 ♀; Rudersberg, Steinenberg, 48.8677° N, 9.5523° E, 07 May 1997, substrate sampling, leg. & det. JS (JSC) 1 ♂, 3 ♀; Tengen, Riedbachtal, 47.8115° N, 8.6491° E, 29 May 1997, substrate sampling, leg. & det. JS (JSC) 1 ♀; Vöhrenbach, Linach-Stausee, meadow, 48.0151° N, 8.3113° E, 16 April 1993, flotation process, leg. & det. JS (JSC) 1 ♂. **Saxony**: Hirschfelde, Neisse Valley, deciduous forest, 50.9896° N, 14.9172° E, soil cores, leg. & det. WD (SMNG) 02 June 1961, 1 L3; 27 July 1961, 1 L5; Waltersdorf, Lausche, calcareous beech forest, 5–10 cm soil depth, 50.8507° N, 14,6650° E, 30 April 2012, leg. & det. UB (SMNG) 1 L9.

Decapauropus cuenoti is widely distributed in the western Palearctic, but also in the USA and some oceanic islands, and shows a broad spectrum of biotopes without visible preferences. In Europe the species occurs in deciduous forests (from dry oak-hornbeam forest, through moist beech and mixed deciduous woods to very wet floodplain forests) as well as in coniferous forests (*Picea*). Dry meadows and wasteland were colonized as well as fresh meadows. Also vineyards, gardens and open-cast mining sites were not avoided. Cited by Remy and Hoffmann (1959), Chalupský (1967), Dunger (1968), Dizdarević (1975, 1977), Hüther (1982), Scheller (1954, 1962, 1976) and Krauß et al. (1998). According to Hüther & Kinkler (2013) this species mostly occurs in low numbers albeit widespread. *D. cuenoti* is found in the litter layer, in grass sods, under stones and moss, and also directly in (mostly loamy) soil. Non-calcareous soil can also be colonized by this species (Scheller 1977a, 1982). According to Dizdarević (1971) it prefers the deeper soil layers from 15 cm to 55 cm depth.

Decapauropus distinctus (Bagnall, 1936)

Previous Record. **Baden-Württemberg**: Triberg im Schwarzwald, 1–2 June 1936 (Remy 1936a).

New Records. **Baden-Württemberg**: Ulm, Herrlingen, Kiesental, 48.4247° N, 9.9082° E, 6 May 1997, substrate sampling, leg. & det. JS (JSC) 1 ♂, 2 ♀; Esslingen, Strümpfelbacher Steige, 48.7515° N, 9.3277° E, 28 December 1990, hand sampling, leg. & det. JS (JSC) 1 ♀; Schelklingen, Sotzenhausen, 48.3726° N, 9.7586° E, 4 August 1993, substrate sampling, leg. & det. JS (JSC) 1 juv.

This species is widespread in Europe, but also known from North Africa and the USA. It was first recorded for Germany by Remy (1936a) from Triberg (Baden-Württemberg) and later confirmed from other parts of Baden-Würtemberg. It is often found in agricultural soil in gardens and in greenhouses (Remy 1941, 1961b, Chalupský 1976, Scheller 1976). Records from forests are rare (Remy 1960, 1961b). In Baden-Württemberg the species was found in a shrubbery near orchards and in two former quarries, now shrubberies. The new record from Bavaria in a doline within alpine meadows at an altitude of 1300 to 1500 m a. s. l. represents the highest known occurrence of a pauropod in Germany.

Decapauropus doryphorus (Remy, 1936)

non *A. doryphorus* Krestewa, 1940

Record. **Saarland**: Wadgassen, mine heap, *Robinia* afforestation, 1975–1976 (Guttmann 1979).

In Germany this species is only recorded from a former mine dump, recultivated with *Robinia* (Guttmann 1979). This rare species is also known from Greece and North Africa. The only note on habitats is given by Remy (1936b): under leaves of a hedge (Greece/Thessaly/Kalabaka).

Decapauropus gracilis (Hansen, 1902)

Previous Records. Between Rhine and Saar, surroundings of Bochum and Braunschweig [general information on collection sites for all species treated in this publication], 1955–1961 (Hüther 1974); **Baden-Württemberg**: Ulm, Langenau, spruce

forest, after windthrows, not cleared, 1996 (Krauß et al. 1998, JSC); Bad Griesbach im Schwarzwald, 24 February 1936 (Remy 1938); Bad Waldsee, spruce and beech forest, 1996 (Krauß et al. 1998, JSC); Tübingen, Bebenhausen, spruce forest, after windthrows, not cleared, 1996 (Krauß et al. 1998, JSC); Endingen am Kaiserstuhl, Katharinaberg, 25 April 1961 (Scheller 1962); Freiburg im Breisgau, Schloßberg, 1 August 1937 (Remy 1938); Hausach, 02 June 1936 (Remy 1936a); Schelingen, Badberg, 23 April 1961 (Scheller 1962); Schelingen, Vogelsang, deciduous forest, 23 April 1961 (Scheller 1962); Triberg im Schwarzwald, 1–2 June 1936 (Remy 1936a); Triberg im Schwarzwald, Prisenhäusle, under rotting planks, 2 June 1936 (Remy 1938). **Berlin**: Berlin-Zehlendorf, Grunewald, NSG Langes Luch, swamp forest, 1972–1974 (Haupt 1973, 1977). **Hamburg**: Langenhorn, wasteground, 6 June 1957 (Haß 1958). **Hesse**: Marburg (Hansen 1902). **North Rhine-Westphalia**: Leverkusen, Gronenborn, NSG Gronenborner Teiche, 2005–2011 (Hüther & Kinkler 2013). **Rhineland-Palatinate**: Mainz, vineyard (Hüther 1959); Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982). **Saarland**: Wadgassen, mine heap, *Robinia* afforestation and ruderal area, 1975–1976 (Guttmann 1979). **Saxony**: Leipzig, Böhlen, dump with deciduous afforestations eight and 11 year-old, 51.202° N 12.387° E, soil cores, 0–5 and 5–10 cm soil depth, leg. & det. WD (SMNG, Dunger 1966, 1968) 24 October 1962 1 L3, 1 L8, 3 September 1963 2 L9, 15 August 1965 1 L9, 1 ♀; Görlitz, Berzdorf-Tauchritz, Langteichhalde, brown coal open-cast mine dump with deciduous afforestations 7–10 year-old, 51.065° N, 14.932° E, soil cores, 0–5 and 5–10 cm soil depth, leg. & det. WD (SMNG, Dunger 1966, 1968) 21 April 1961, 1 L8, 3 ind.; 20 August 1962, 2 L3, 2 L5, 2 L6, 1 L7, 3 L8, 4 L9; 17 September 1962, 4 L3, 3 L6, 5 L9; 12 November 1962, 1 L5, 1 L6, 1 L9; 23 July 1962, 3 L3, 1 L5; 30 April 1965, 1 L6, 1 L9; 21 May 1965, 1 L9; Görlitz, Berzdorf-Tauchritz, Langteichhalde, brown coal open-cast mine dump with afforestation with *Larix decidua* 10 year-old, 51.065° N, 14.932° E, 30 July 1962 soil cores, 0–5 and 5–10 cm soil depth, leg. & det. WD (SMNG, Dunger 1966, 1968) 1 L3, 1 L6; Görlitz, Kiesdorf, floodplain forest, 51.0391° N, 14.8838° E, soil cores, 0–5 and 5–10 cm soil depth, leg. & det. WD (SMNG, Dunger 1966, 1968) 16 July 1962, 1 L3; 10 September 1962 (det. J. Chalupský), 6 Bp; 26 November 1962, 1 L8 , 1 L9; [cf.] Görlitz, Berzdorf-Tauchritz, Langteichhalde, brown coal open-cast mine dump with deciduous afforestations six year-old, 51.065° N, 14.932° E, 8 September 1961, soil core, 0–5 cm, leg. & det. WD (SMNG) 1 L3.

New Records. **Baden-Württemberg**: Ulm, Herrlingen, Kiesental, 48.4247° N, 9.9082° E, 06 May 1997, substrate sampling, leg. & det. JS (JSC) 2 ♂, 6 ♀; Neidlingen, Reußenstein, 48.5662° N, 9.5704° E, 1 May 1997, substrate sampling, leg. & det. JS (JSC) 3 ♀; Riesbürg, Goldburghausen, Goldberg, 48.8628° N, 10.4244° E, 9 April 1997, substrate sampling, leg. & det. JS (JSC) 1 ♂; Tengen, Riedbachtal, 47.8115° N, 8.6491° E, 29 May 1997, substrate sampling, leg. & det. JS (JSC) 1 ♂, 1 ♀; Waiblingen, Hart, 48.8558° N, 9.2878° E, 14 January 1989, hand sampling, leg. & det. JS (JSC) 1 ♀; Plettenberg, Pyrola-Piceetum, 48.2° N, 8.8° E, 01 August 1998, substrate sampling, leg. & det. JS (JSC) 1 ♀, 3 juv. **Bavaria**: Jetzendorf, ropes course, 48.4405° N, 11.4201 ° E, 14 July 2013, flotation process, leg. & det. JS (ZSM) 1 ad., 1 ♂. **Brandenburg**: [cf.] Großräschen, pine forest, 51.576° N, 14.011° E, 11 November 1968, pitfall trap, leg. & det. WD (SMNG) 1 L5. **Hesse**: Wettenberg, Launsbach, canal embankment between Silbersee – Lahn, under willows, in soil near a concrete wall, 50.6136° N, 8.6732° E, 14 March 2014, leg. AA, det. UB (SMF) 1 L9; Guxhagen, Eder near Grifte, deciduous forest, slope, in dry loose soil under *Urtica*, 50.2879° N, 9.3652° E, 6 July 2014, leg. AA, det. UB (SMF) 1 L9. **Saxony**: Löbau, Löbauer Berg, beech forest, 51.0933° N, 14.6966° E, 21 April 2011, soil corer, leg. & det. UB (SMNG) 1 subad.; Görlitz, Hirschfelde, Neisse Valley, deciduous forest, 50.9896° N, 14.9172° E, soil cores, leg. & det. WD (SMNG) 02 June 1961, 1 L9; 30 June 1961, 1 L6; 25 August 1961, 1 L3, 1 L6; 7 November 1961, 1 ♂; 15 December 1961, 1 L8; Görlitz, Hirschfelde, Neisse Valley, spruce forest, 50.9667° N, 14.9030° E, soil cores, leg. & det. WD (SMNG) 30 June 1961, 1 L6; 27 July 1961, 1 L5; [cf.] Hirschfelde, Neisse Valley, deciduous forest, 50.9896° N, 14.9172° E, soil cores, leg. & det. WD (SMNG) 02 June 1961, 1 L9; 5 May 1961, 1 L9; 17 November 1961, 2 L9; [cf.] Hirschfelde, Neisse Valley, spruce forest, 50.9667° N, 14.9030° E, soil cores, leg. & det. WD (SMNG) 16 April 1962, 1 L8; 20 October 1961, 1 L5; 17 November 1961, 1 L3, 1 L6; 2 L8; Nochten, experimental area for succession study surrounded by meadow dominated by *Dactylis glomerata*, arthropod-free mining substrate from coal mine excavated from 2 m depth in March 2008, cambic Umbisol, gravelly sand, pH 5.2–5.3, 51.4892° N, 14.5756° E, leg. R. Lehmitz, minicontainer-traps, det. UB (SMNG, for more information on the study site and soil parameters see Lehmitz et al. 2012); 14 September 2008, 3 L9, 2 L6; 14 September 2008, 1 L9, 1 L6. **Thuringia**: Jena, Leutratal, Mesobrometum, 50.8722° N 11.5678° E, 19 June 1974, soil core, leg. & det. WD (SMNG) 1 L9.

Decapauropus gracilis is one of the most common species in Central Europe. It occurs in deciduous and also in coniferous forests (e.g. Chalupský 1967, Haupt 1973, Hüther 1982, Krauß et al. 1998, Scheller 1977a, Remy 1960 and new records presented here). Sites with moder-humus (Dunger 1968) and an abundance of dead wood (Hüther & Kinkler 2013) seem to be preferred. But there exist also records from dry meadows and pastures (Hüther 1982, Scheller 1977a). Occurrences in caves (e.g. Kováč et al. 2014) and greenhouses (Remy 1936b; also cited by Eichler 1952) are known. An altitude of 900 m a. s. l. seems to be a limiting factor for the occurrence of *D. gracilis*

(Chalupský 1967), at least in Central Europe. It occurs both under stones and bricks, in the soil, in leaf litter and rotting tree logs and stumps. In addition to clay soils, sandy soils can also be colonized by *D. gracilis*, e.g. in Finland and Great Britain (Scheller 1974, 1982) as well as the new records from Nochten (Germany). According to Dizdarević (1971) it prefers the upper soil layer down to 30 cm, but occurs down to 60 cm depth. In arable land in Great Britain, investigations show most occurrences from 20 to 30 cm (Scheller 1974). In contrast the SMNG material from Berzdorf (Saxony) showed that for the most frequently occurring species, *D. gracilis*, 70% of the specimens were found in the uppermost soil layer of 0 to 5 cm (studied only up to 10 cm depth).

There exist a number of subspecies and variations, e.g. *D. amaudruti* Remy, 1936, *D. sabaudianus* Remy, 1935, and *D. sequanus* Remy, 1930, in Germany. Because *D. gracilis* May comprise a species group (Hüther 1982), the ecological reqirements are given here separately:

Decapauropus amaudruti is found almost exclusively in open lands (dry meadows with *Rosa canina* and *Sarothamnus scoparius*, see Hüther 1982; freshly heaped dumps of open cast mining, see Dunger 1968). Only scattered records come from a beech forest and a floodplain forest (l.c.). One occurrence in a greenhouse is known (Botanical Garden in Strasbourg, Remy 1936b, also cited by Eichler 1952). *D. amaudruti cordieri* Remy 1938 is also listed as a species by some authors. According to Dizdarević (1971) it occurs in the same soils as *D. gracilis*, but is restricted to Fagetalia (Dizdarević 1977, Remy & Balland 1958).

Decapauropus sabaudianus occurs in woods and in gardens (Remy 1960, 1941, 1962, Scheller 1954). In investigated dumps (Guttmann 1979) it colonized a *Robinia* afforestation and an open-land site with high and well developed herb layer. A preference for calcareous soils seems to exist according to records from soil or under stones (Remy 1936a, 1941, 1939, Hüther 1959).

Decapauropus sequanus is known from calcareous beech woods and other deciduous forests (Remy 1939, Scheller 1962) as well as from non-natural locations (under rotten planks, Remy 1938). In Denmark *D. sequanus* is found mostly in gardens (Scheller 1954).

Decapauropus helophorus (Remy, 1936)

Records. **Bavaria**: Würzburg (Hüther 1982). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

This species is widespread in Europe (Portugal to Bulgaria) and was found in forests (Chalupský 1967, Dizdarević 1971) as well as very open biotopes like south facing dry meadows (Hüther 1982). *D. helophorus* was collected in the soil and litter layer.

Decapauropus helveticus (Hansen, 1902)

Previous Records. **Baden-Württemberg**: Bad Griesbach im Schwarzwald, 24 February 1936 (Remy 1938); Schelingen, Vogelsang, deciduous forest, 23 April 1961 (Scheller 1962); Endingen am Kaiserstuhl, Katharinaberg, 25 April 1961 (Scheller 1962); Schelingen, Badberg, 23 April 1961 (Scheller 1962). **Bavaria**: Freising, Eichenfeld, Plantage, 3 July 2005 (Spelda 2005). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

New Records. **Baden-Württemberg**: Ulm, Herrlingen, Kiesental, 48.4247° N, 9.9082° E, 6 May 1997, substrate sampling, leg. & det. JS (JSC) 1 ♂; Tengen, Riedbachtal, 47.8115° N, 8.6491° E, 29 May 1997, substrate sampling, leg. & det. JS (JSC) 1 ♀.

Decapauropus helveticus s. str. is not known from outside Europe (Scheller 1973), nor is it very common (e.g. Scheller 1982, Chalupský 1967). The biotope spectrum ranges from south-facing dry meadows, submediterranean garrigue vegetation (e.g. *Cisto-Ericetalia* in Bosnia and Herzegovina), over wet grassland and shrubs, up to deciduous forests (Hüther 1982, Dizdarević 1971,

Remy 1962, Scheller 1977a). Urban areas are not avoided, e.g. the vicinity of Prague (Chalupský 1967). *D. helveticus* is often found under stones and bricks lying on soil or grass, in soil, near the base of steep rocks, but rarely in leaf litter. The soil is in most cases loamy, but in Finland the species was also found at a location with sandy mull (Scheller 1982). The German fauna also includes the variety *obtusicornis* (Remy, 1935). As the taxonomical status of this variety is still in dispute, we here separate the data from *D. helveticus* s. str.

Previous Records. **Baden-Württemberg**: Freiburg im Breisgau, Schloßberg, 1 August 1937 (Remy 1938); Triberg im Schwarzwald, 1–2 June 1936 (Remy 1936a); **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

New Record. **Bavaria**: Törwang, Samerberg, Hochries, dolines, 1300–1499 m, 47.6317° N, 12.1589° E, 8 October 2014, hand sampling, leg. & det. JS (ZSM) 2 ad., 2 ♂, 1 ♀.

This taxon is distributed throughout Europe and also occurs in North Africa and North America (Scheller 1973). Preferred biotopes seem to be open land with sparse vegetation on loamy soils (e.g. dry meadows, lush pastures, apple orchards, gardens (Hüther 1982, Scheller 1954, 1973), mostly under stones and in the soil. In Finland an area with sparse vegetation on sandy mull was colonized by this species (Scheller 1982).

Decapauropus hessei (Remy, 1935)

Record. **Baden-Württemberg**: Nordheim, 3 km NE of Neipperg, 19 April 1997 (Spelda 2005).

This rare species has not been reported from outside of central and southern Europe (Scheller 1976). It was recorded from Baden-Württemberg for the first and so far only time (Spelda 2005). The species was mostly recorded in beech forests (Remy 1946, 1961b, Chalupský 1967) where it was found in the litter and rotting logs. The German record originates from a soil sample at the border between a forest and a field on shell limestone (Middle Triassic).

Decapauropus kocheri (Remy, 1954)

Record. **Saarland**: Wadgassen, mine heap, *Robinia* afforestation and ruderal area, 1975–1976 (Guttmann 1979).

This rare species has been recorded from Africa and India. For Germany, *D. kocheri* is only known from a recultivated dump in Saarland (Guttmann 1979) at a site with dense graminaceous vegetation, in places with dense moss pads and in a stand of afforested *Robinia*.

Decapauropus meridianus (Remy, 1941)

Record. **Baden-Württemberg**: Schelingen, Badberg, 23 April 1961 (Scheller 1962).

The species has not been reported outside of Europe. It was found only one time in Germany by Scheller (1962). Elsewhere in the distribution area there exist only sporadic records from France (Remy 1941, 1946, 1961b).

Decapauropus multiplex (Remy, 1936)

Previous Records. **Baden-Württemberg**: Bad Griesbach im Schwarzwald, 24 February 1936–28 August 1936 (Remy 1936a); Endingen am Kaiserstuhl, Katharinaberg, 25 April 1961 (Scheller 1962); Triberg im Schwarzwald, 1–2 June 1936 (Remy 1936a); **Saxony**: Görlitz, Berzdorf, brown coal mine, dump with deciduous afforestation three year-old, 12 June 1962, det. J. Chalupský, 1 ind., 3 September 1962 1 ind. (Dunger 1968).

New Records. **Baden-Württemberg**: Ulm, Herrlingen, Kiesental, 48.4247° N, 9.9082° E, 6 May 1997, substrate sampling, leg. & det. JS (JSC) 3 ♂, 1 ♀; Neidlingen, Reußenstein, 48.5662° N, 9.5704° E, 1 May 1997, substrate sampling, leg. & det. JS (JSC) 1 ♂.

Remarks. There May be more individuals of *D. multiplex* from Berzdorf in the collection of SMNG labeled as cf. *danicus*/*multiplex*. A revision of the material is intended.

The species is only known from the Western Palaearctic and is not very frequently occurring (Scheller 1977a). It was found in deciduous forests, gardens and arable land (Chalupský 1967, Dunger 1968, Scheller 1954, 1974, 1976). Often *D. multiplex* is found in litter (oak, beech), but also in the (loamy) soil, under stones and at the base of steep rocks as well as under bark of rotting logs (Remy 1962, Chalupský 1967, Scheller 1977a). It occurs mostly in the upper soil layer up to 24 cm soil depth (Scheller 1974).

Decapauropus tenellus (Scheller, 1971)

Previous Record. **Baden-Württemberg**: Schelklingen, Sotzenhausen, 4 August 1993 (Spelda 2005).

New Record. **Hesse**: [cf.] Gießen, meadow under highway B429 bridge, under grass on basalt stones, 50.56525° N, 8.65415° E, 21 July 2014, leg. AA, det. UB (SMF) 1 L10.

This species is probably rare but might be widespread (Sweden, Norway, Finland, France, Scheller 1982), as it is very similar to *D. vulgaris*, thus probably often confused with this species. In the Pyrenees it was found in a lush pasture near a stream at a depth of 10 to 15 cm (Scheller 1973), in Finland in a herb-rich birch forest and on a grazed ridge with mountain ash and alder (Scheller 1982). The first German specimen (Spelda 2005) was found in a former quarry, now a dry meadow with sparse stocks of pine, the second also in a meadow.

Decapauropus thalassophilus (Remy, 1935)

Records. **Rhineland-Palatinate**: Pfalz (Guttmann 1979). **Saarland**: Wadgassen, mine heap, ruderal area, 1975–1976 (Guttmann 1979).

The main distribution area of this species is in France (Remy 1936b, 1941, 1946, 1961b, Scheller 1973). In Germany *D. thalassophilus* is known from a dump in the Saarland where it was found on a ruderal site with high and well developed herb layer (Guttmann 1979). In France the species was mostly found in forests (e.g. Remy 1961b), but the first find was on the seashore under rotting *Posidona* debris (Remy 1935).

Decapauropus viticolus Hüther, 1975

Records. Between Rhine and Saar, surroundings of Bochum and Braunschweig [general information on collection sites for all species treated in this publication], 1955–1961 (Hüther 1974); **Rhineland-Palatinate**: Bad Dürkheim, vineyard, 29 May 1957 (Hüther 1975); Edesheim, vineyard, 1957–1958 (Hüther 1975).

The species was described from a vineyard in Germany and from another locality in Norway (Hüther 1975). The occurences within the vineyard were restricted to sites which were characterized by cambisol. The species was found only in the deeper soil layer from 20 to 50 cm (Hüther 1974).

Decapauropus vulgaris (Hansen, 1902)

Previous Records. Between Rhine and Saar, surroundings of Bochum and Braunschweig [general information on collection sites for all species treated in this publication], 1955–1961 (Hüther 1974); **Baden-Württemberg**: Bad Griesbach

im Schwarzwald, 28 June 1936 (Remy 1938); Bad Peterstal, 28 June 1936 (Remy 1936a); Baden-Baden, 6 June 1937 (Remy 1938); Endingen am Kaiserstuhl, Katharinaberg, 25 April 1961 (Scheller 1962); Freiburg im Breisgau, Schloßberg, 01 August 1937 (Remy 1938); Hausach, 2 June 1936 (Remy 1936a); Schelingen, Badberg, 23 April 1961 (Scheller 1962); Schelingen, Vogelsang, deciduous forest, 23 April 1961 (Scheller 1962); Triberg im Schwarzwald, 1–2 June 1936 (Remy 1936a); Tübingen, Bebenhausen, spruce forest, after windthrows, not cleared, 1996 (Krauß et al. 1998, JSC). **Bavaria**: Freising, Eichenfeld, Plantage, 3 July 2005 (Spelda 2005); Rosenheim, Reschmühlbachstausee, 17 June 2005 (Spelda 2005). **Berlin**: Berlin-Zehlendorf, Grunewald, NSG Langes Luch, swamp forest, 1972–1974 (Haupt 1973, 1977). **North Rhine-Westphalia**: Leverkusen, Gronenborn, NSG Gronenborner Teiche, 2005–2011 (Hüther & Kinkler 2013). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982). **Saxony**: Görlitz, Berzdorf-Tauchritz, Teichhalde, brown coal open-cast mine dump with three year-old deciduous afforestations, 51.065° N, 14.939° E, soil cores, 0–5 cm and 5–10 cm soil depth, leg. & det. WD (SMNG, Dunger 1966, 1968) 14 May 1962, 1 ind.; 12 June 1962, 1 ind. (det. J. Chalupský); 6 August 1962, 1 L3; Leipzig, Böhlen, brown coal mine, heap, poplar/black alder afforestation, 1960–1963 (Dunger 1968); Görlitz, Kiesdorf, floodplain forest, 1960–1963 (Dunger 1968, see also Dunger 1966).

New Records. **Baden-Württemberg**: Ulm, Herrlingen, Kiesental, 48.4247° N, 9.9082° E, 6 May 1997, substrate sampling, leg. & det. JS (JSC) 2 ♂, 7 ♀, 3 juv.; Nordheim, 3 km NE Neipperg, 49.1162° N, 9.0863° E, 19 April 1997, substrate sampling, leg. & det. JS (JSC) 1 ♂, 6 ♀; Vöhrenbach, Linach-Stausee, meadow, 48.0151° N, 8.3113° E, 16 April 1993, flotation process, leg. & det. JS (JSC) 1 ♂, 1 ♀; Ludwigsburg, garden, compost heap, 48.910443° N, 9.173799° E, 7 April 2011, substrate sampling, leg. & det. UB (SMNG). **Bavaria**: Eichstätt, 48.9034° N, 11.1565° E, 25 June 2005, flotation, leg. & det. JS (JSC) 1 juv. ♂. **Hesse**: Wetzlar, Blasbach, river bank, under grass and leaves, 50.5914° N, 8.5002° E, 6 June 1987, leg. AA, det. UB (SMF) 1 L9; Guxhagen, Eder near Grifte, deciduous forest, slope, in dry loose soil under *Urtica*, 50.2879° N, 9.3652° E, 6 July 2014, leg. AA, det. UB (SMF) 1 L8; Laubach, Hirtenbach, river bank, under grass at bridge wall, 50.5437° N, 9.01006° E, 27 April 2014, substrate sampling, leg. AA, det. UB (SMF) 2 ♂, 1 L9; Laubach, Schellenbach, river bank, under grass at bridge wall, 50.5437° N, 9.01006° E, 27 April 2014, substrate sampling, leg. AA, det. UB (SMF) 1 L9; Bad Homburg, Ober-Erlenbach, Erlenbach, river bank, 50.22° N, 8.68° E, 7 April 1988, leg. AA, det. UB (SMF) 1 L10. **Mecklenburg-Western Pommerania**: Rostock, Lütten-Klein, Unterwarnow-Aue, Alte-Warnemünde-Chaussee, channel, boggy river bank, under willows, in humus, 54.12° N, 12.06° E, 25 June 2014, leg. H. Nesemann, det. UB (SMF) 1 L9. **North Rhine-Westphalia**: Langerscheid, spruce forest, 50.52131° N, 6.34056° E, 7 May 2014, soil core, 0–5 cm, leg. SMNG, det. UB (SMNG) 1 L8; Schlitterley, oak forest, 50.62028° N, 6.49382° E, 7 May 2014, leg. SMNG, det. UB (SMNG) 1 ♂.

This species is widespread and common in Europe. According to Hüther (1974) *D. vulgaris* is very eurytopic but mainly colonizes biotopes with a closed plant cover with a preference for coniferous forests. However, in its overall distribution area records from deciduous forests predominate (Haupt 1973, 1977, Dizdarević 1971, 1975, 1977, Loksa 1966, Chalupský 1967, Dunger 1968, Krauß et al. 1998). Occurrences in dry meadows, arable land and gardens are also known (Scheller 1954, Hüther 1974, 1982, Scheller 1974). But all these locations have calcareous soil in common (e.g. lessivé, stagno-gleyic lessivé, rendzic leptosol). This seems to be a precondition for occupation by *D. vulgaris*. Hüther (1974) found the species mostly in soil depth from 10 to 50 cm but also under decaying wood. According to Dizdarević (1971) it prefers the upper soil layer (5 to 10 cm), but occurs sporadically up to 60 cm depth.

Pauropus bagnalli Remy, 1935

Records. **Baden-Württemberg**: Hausach, 2 June 1936 (Remy 1936a); Triberg im Schwarzwald, 1–2 June 1936 (Remy 1936a).

The species was described from the Vosges (Remy 1935) and was found in adjacent regions in Baden-Würtemberg. All later citations refer to these records (e.g. Gisin 1947, Schubart 1963). Only Chalupský (1967) gives a note on habitat: from a beech primeval forest, in litter and rotting timber.

Pauropus furcifer Silvestri, 1902

Previous Records. **Baden-Württemberg**: Bad Griesbach im Schwarzwald, 24 February 1936 – 28 August 1936 (Remy 1936a, 1938); Bad Peterstal, 28 June 1936 (Remy 1938); Triberg im Schwarzwald, 1–2 June 1936 (Remy 1936a); Schelingen, Badberg, 23 April 1961 (Scheller 1962).

New Records. **Hesse**: Schöffengrund, bank on the Wetzbach near Streichs-Mühle, under moss and grass, 50.49945° N, 8.491° E, 27 June 1987, leg. AA, det. UB (SMF) 1 L9. **Thuringia**: [cf.] Jena, Leutratal, deciduous wood, 50.8722° N, 11.5678° E, 24 May 1972, soil core, leg. & det. WD (SMNG) 1 L3.

P. furcifer is widespread in western, central and southern Europe. It is almost exclusively known from deciduous and coniferous forests (Chalupský 1961, 1967, Dizdarević 1977, Scheller 1973, 1977a) and has been found in moist leaf and coniferous litter, under stones, at the base of steep rocks, in the soil, under bricks and in moss. Occurences in caves are also known (Remy & Husson 1938, Griepenburg 1939). According to Dizdarević (1971) the species prefers the upper soil layer 0 to 20 cm whilst it occurs up to 60 cm depth.

Pauropus huxleyi Lubbock, 1867

Previous Records. Between Rhine and Saar, surroundings of Bochum and Braunschweig [general information on collection sites for all species treated in this publication], 1955–1961 (Hüther 1974). **Baden-Württemberg**: Bad Griesbach im Schwarzwald, 24 February 1936 – 28 August 1936 (Remy 1936a); Bad Peterstal, 28 June 1936 (Remy 1936a); Baden-Baden, 6 June 1937 (Remy 1938); Tübingen (Hansen 1902); Endingen am Kaiserstuhl, Katharinaberg, 25 April 1961 (Scheller 1962); Freiburg im Breisgau, Schloßberg, 1 August 1937 (Remy 1938); Hausach, 2 June 1936 (Remy 1936a); Oppenau, Rehberg, 25 February 1936 (Remy 1936a); Schelingen, Badberg, 23 April 1961 (Scheller 1962); Schelingen, beech forest, 23 April 1961 (Scheller 1962); Schelingen, Vogelsang, deciduous forest, 23 April 1961 (Scheller 1962); Triberg im Schwarzwald, 1–2 June 1936 (Remy 1936a). **Bavaria**: Weissenburg, Laubenthal, 25 June 2005 (Spelda 2005, specimens not checked); **Hamburg**: Horn, under bark of linden tree, 23 October 1932 (Haß 1958). **Hesse**: Marburg (Hansen 1902); Petersberg, Felsenkeller am Rauschenberg, adit, 12 July 1996 (Zaenker 2008). **North Rhine-Westphalia**: Leverkusen, Gronenborn, NSG Gronenborner Teiche, 2005–2011 (Hüther & Kinkler 2013).

New Records. **Baden-Württemberg**: Forchtenberg, 49.2784° N, 9.5541° E, 3 April 1997, hand sampling, leg. & det. JS (JSC) 1 L6; Rudersberg, Steinenberg, 48.8677° N, 9.5523° E, 7 May 1997, substrate sampling, leg. & det. JS (JSC) 1 ♀, 1 L8.

The specimens of Krauß et al. (1998) have been re-examined and assigned to the correct species (*P. lanceolatus*). Because *P. huxleyi* has been often confused with *P. lanceolatus* Remy, 1937 it is now impossible to delimit its distribution area according to Scheller (1977a) and Hüther and Kinkler (2013). They recommend all records before 1937 to be re-checked. This species is known as a common inhabitant of forests and floodplains in soil, litter, rotting timber and under stones (Latzel 1884, Chalupský 1967, Loksa 1966, Hüther 1974, Scheller 1954, 1973, 1977a). Hüther (1974) found it often in open land, but rarely in vineyards.

Pauropus lanceolatus Remy, 1937

Previous Records. Between Rhine and Saar, surroundings of Bochum and Braunschweig [general information on collection sites for all species treated in this publication], 1955–1961 (Hüther 1974). **Baden-Württemberg**: Baden (region) (Remy 1938); Schelingen, Vogelsang, deciduous forest, 23 April 1961 (Scheller 1962); Schelingen, Badberg, 23 April 1961 (Scheller 1962). **Hamburg**: Hamburg (Remy 1938). **Hesse**: Marburg (Remy 1938). **Lower Saxony**: Clausthal-Zellerfeld, Clausthaler Gruben, adit, 1936 (Remy 1938, Mühlmann 1942). **Rhineland-Palatinate**: Mainz, compost heap (Hüther 1959, Remy 1961b); Niederzissen, Bausenberg, 1976–1979 (Hüther 1982); Otterberg, Stollen am Messersbacherhof, adit, 17 July 1988 (Weber 1995, 2001, 2012).

New Records. **Baden-Württemberg**: 4 km E Schriesheim, 49.4788° N, 8.7142° E, 28 April 1998, substrate sampling, leg. & det. JS (JSC) 1 ♂, 1 L8; Kirchardt, Berwangen, 49.1837° N, 8.9986° E, 19 April 1997, hand sampling, leg. & det. JS (JSC) 1 ♀; Schwäbisch Gmünd, Degenfeld, 48.7325° N, 9.8741° E, 2 May 1994, hand sampling, leg. & det. JS (JSC) 3 ♂, 2 ♀, 1 L8; Weinstadt, Pfaffenholz, 48.7952° N, 9.4301° E, 3 October 1990, substrate sampling, leg. & det. JS (JSC) 1 L8; Altdorf, Silbersandgrube, spruce forest, 9.0216° E, 48.5865° N, 4 June 1996, substrate sampling, 6 ♂, 3 ♀; same data, after windthrows, cleared, 3 ♂, 2 ♀; same data, after windthrows, not cleared, natural regeneration, 1 ♂, 1 ♀; same data, 26 November 1996, spruce forest, 1 L6; same data, after windthrows, cleared, 3 ♂, 8 ♀, 8 L8, 3 L6; same data, after windthrows, not cleared, natural regeneration, leg. & rev. JS (JSC) (all wrongly cited as *P. huxleyi* for Bebenhausen

in Krauß et al. 1998); Neidlingen, Reußenstein, 48.5662° N, 9.5704° E , 1 May 1997, substrate sampling, leg. & det. JS (JSC) 1 ♀; Neidlingen, Bahnhöfle, 48.55° N, 9.55° E , 27 June 1998, substrate sampling, leg. & det. JS (JSC) 3 L8, 3 L6, 2 L5; ♀; Gomadingen, Gestüt Marbach, 48.3897° N, 9.4199° E, 21 August 1993, hand sampling, leg. & det. JS (JSC) 1 ♀; Langenau, Englenghäu, 48.5192° N, 10.0559° E, 1 November 1994, substrate sampling, leg. H. Bellmann, det. JS (JSC) 3 ♂; Langenau, Englenghäu, 10.0559° E, 48.5192° N, 29 October 1996, substrate sampling, leg. & rev. JS 1 ♂, 1 ♀, 1 L8 (wrongly cited as *P. huxleyi* for Langenau in Krauß et al. 1998); Schelklingen, Sotzenhausen, 48.3726° N, 9.7586° E, 4 August 1993, substrate sampling, leg. & det. JS (JSC) 1 ♂, 3 ♀; Wolpertswende, Röschenwald, 9.6436° E, 47.9011° N, 29 October 1996, substrate sampling, leg. & rev. J. Spelda (JSC) 2 ♀ (wrongly cited as *P. huxleyi* for Bad Waldsee in Krauß et al. 1998); Isny im Allgäu, Luegensland, 47.6891° N, 10.0966° E, 27 August 1990, hand sampling, leg. & det. JS (JSC) 1 L8. **Bavaria**: Jetzendorf, ropes course, 48.4405° N, 11.4201 ° E, 14 July 2013, flotation process, leg. & det. JS (ZSM) 1 ♂, 1 ♀.

Pauropus lanceolatus is known to occur from Norway to France and reported as well from USA and Australia. It is mostly found in coniferous as well as deciduous forests, although it also occurs in dry meadows, quarries, vineyards, arable land and in compost heaps (Hüther 1959, 1974, Scheller 1974, 1982, Leinaas 1974). It is one of the few pauropods which occur occasionally in high abundances (Hüther 1974). In Norwegian coniferous forests the species was mainly found in the humus horizon (up to 9 cm) and even in living moss (Leinaas 1974).

Stylopauropus pedunculatus (Lubbock, 1867)

Previous Records. **Baden-Württemberg**: Schelingen, Badberg, 23 April 1961 (Scheller 1962). **Bavaria**: Eichstätt, Blumenberg, 25 June 2005 (Spelda 2005); Weissenburg, Laubenthal, 25 June 2005 (Spelda 2005); Freising, Marzlinger Au, 30 April 2005 (Spelda 2005); Rosenheim, Reschmühlbachstausee, 17 June 2005 (Spelda 2005). **North Rhine-Westphalia**: Leverkusen, Gronenborn, NSG Gronenborner Teiche, 2005–2011 (Hüther & Kinkler 2013). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September1979 (Hüther 1982). **Saarland**: Wadgassen, mine heap, *Robinia* afforestation, 1975–1976 (Guttmann 1979). **Saxony**: Görlitz, Kiesdorf, floodplain forest, 51.0391° N, 14.8838° E, 13 August 1962, soil core, 0–5 cm soil depth, leg. WD, det. WD & J. Chalupský (SMNG, Dunger 1966, 1968) 1 ind. **Saxony-Anhalt**: Rübeland, Hermannshöhle, cave, 1936 (Remy 1938, Mühlmann 1942); Rübeland, Baumannshöhle, cave, 1936 (Remy 1938, Mühlmann 1942); Rübeland (Griepenburg 1939).

New Records. **Baden-Württemberg**: Neuffen, Balzholz, 48.5643° N, 9.3875° E, 7 June 1997, substrate sampling, leg. & det. JS (JSC) 1 ♀; Neuffen, Bäuerloch, 48.5501° N, 9.4001° E, 28 June 1997, substrate sampling, leg. & det. JS (JSC) 1 ♀, 1 juv.; **Bavaria**: Rosenheim, Reschmühlbachstausee, 47.6317° N, 12.1589° E, 17 June 2005, flotation process, leg. & det. JS (JSC) 1 ♀, 1 juv.; Törwang, SSW Grainbach, 12.2331° N, 47.7692° E, 8 October 2014, hand sampling, leg. & det. JS (ZSM) 1 ♂; Benediktbeuern, Lainbach valley, 47.6906° N, 11.4371° E, 17 August 2013, hand sampling, leg. & det. JS (ZSM) 2 juv. **Hesse**: Ehringshausen, river bank at the Dill between Dillheim and Daubhausen, under grass, 50.60375° N, 8.3672° E, 15 August 1987, leg. AA, det. UB (SMF) 1 ♀; Gießen, Heuchelheimer Straße, drainage channel, bridge wall, under blackberry in soil, 50.5836° N, 8.6545° E, 28 February 2014, leg. AA, det. UB (SMF) 1 L9. **Rhineland-Palatinate**: Au am Rhein, Neuhofen, Wildpark, 49.4321° N, 8.4185° E, 24 April 1997, hand sampling, leg. & det. JS (JSC) 1 ♀.

Stylopauropus pedunculatus is a widespread, but not very frequently occurring species in Europe. It can be found in deciduous (oak, beech) and floodplain forests as well as coniferous forests (Remy 1960, Dunger 1968, Dizdarević 1971, 1975, 1977, Guttmann 1979, Loksa 1966, Scheller 1977a, Hüther 1982). In Greece even *Ilex*-forests were colonized (Scheller 1977a). The species also occurs on dry meadows or rocky grassland, but in lower densities than in forests (Loksa 1966, Hüther 1982). As studies in the Dinaric Alps (Bosnia and Herzegovina) show, *S. pedunculatus* reaches up to 1800 m a. s. l. (Dizdarević 1971). Occurrences in caves are also known (Kováč et al. 2014). It is mostly found in soil, under stones, in litter and humus with underlying roots (Scheller 1954, 1977a,).

A variation relevant for Germany is *S. p.* var. *brevicornis* Remy, 1935:

Previous Records. **Baden-Württemberg**: Bad Griesbach im Schwarzwald, 24 February 1936 – 28 August 1936 (Remy 1936a); Bad Peterstal, 28 June 1936 (Remy 1936a); Hausach, 2 June 1936 (Remy 1936a); Oppenau, Rehberg, 25 Febru-

ary 1936 (Remy 1936a); Triberg im Schwarzwald, 1–2 June 1936 (Remy 1936a). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

New Records. **North Rhine-Westphalia**: Overath, Immekeppel, Immekeppel pond, river bank, between roots and leaf litter in sandy soil, 50.9587° N, 7.2390° E, 30 August 2014, leg. AA, det. UB (SMF) 2 L9. **Saxony**: Görlitz, Hirschfelde, Neisse Valley, deciduous forest, 50.9896° N, 14.9172° E, 25 August 1961, soil core, leg. & det. WD (SMNG) 1 ♀; Görlitz, Hirschfelde, Neisse Valley, spruce forest, 50.9667° N, 14.9030° E, 30 June 1961, soil core, leg. & det. WD (SMNG) 2 ♂.

It is mostly found in deciduous forests, where it occurs in litter, under decaying wood, under bark, under stones and in the soil (e.g. Chalupský 1967). Hüther (1982), who treats it as a separate species, found it also on a south-facing slope under shrubs and in a beech wood.

Stylopauropus pubescens Hansen, 1902

Previous Records. **Baden-Württemberg**: Bad Griesbach im Schwarzwald, 24 February 1936 – 28 August 1936 (Remy 1936a); Bad Peterstal, 28 June 1936 (Remy 1936a); Tübingen, Bebenhausen, spruce forest, after windthrows, not cleared, 1996 (Krauß et al. 1998, JSC); Freiburg im Breisgau, Schloßberg, 1 August 1937 (Remy 1938); Schelingen, Badberg, 23 April 1961 (Scheller 1962); Schelingen, beech forest, 23 April 1961 (Scheller 1962); Schelingen, Vogelsang, deciduous forest, 23 April 1961 (Scheller 1962); Triberg im Schwarzwald, 1–2 June 1936 (Remy 1936a). **Bavaria**: Weissenburg, Laubenthal, 25 June 2005 (Spelda 2005); Freising, Marzlinger Au, 30 April 2005 (Spelda 2005). **Hesse**: Marburg (Hansen 1902). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

New Records. **Hesse**: Waldsolms, slope east of Griedelbach, under leaf litter and grass, 50.44815° N, 8.53185° E, 23 May 1987, leg. AA, det. UB (SMF) 1 L8. **Baden-Württemberg**: Neuffen, Bäuerloch, 48.5501° N, 9.4001° E, 28 June 1997, substrate sampling, leg. & det. JS (JSC) 2 ♂; Nonnenmattweiher, Piceetum, 47.7833° N, 7.8° E, 15 August 1998, substrate sampling, leg. & det. JS (JSC) 1 ♂; Tengen, Riedbachtal, 47.8115° N, 8.6491° E, 29 May 1997, substrate sampling, leg. & det. JS (JSC) 1 ♀, 1 juv. ♂.

Stylopauropus pubescens is widespread in Europe and is a typical woodland species (e.g. Remy 1962, Dizdarević 1975, Scheller 1976, Chalupský 1967), which can be found in the soil and under stones.

Scleropauropus lyrifer Remy, 1936

Records. **Baden-Württemberg**: Hausach, Hinterhof, 02 June 1936 (Remy 1936a); Schelingen, Badberg, 23 April 1961 (Scheller 1962).

This species is widely distributed in Europe. *S. lyrifer* occurs in forests (*Fagus*, *Quercus*, *Pinus*, *Picea*) but also in grasslands, like *Arrhenateretes* and *Festucetes* (Chalupský 1967, Gisin 1947, Dizdarević 1971, 1975). Scheller (1977a) found this species at the base of steep rocks.

Family Polypauropodidae

Polypauropus duboscqi Remy 1932

Previous Records. **Saarland**: [cf.] Wadgassen, mine heap, ruderal area, 1975–1976 (Guttmann 1979).

New Records. **Saxony**: Görlitz, Berzdorf-Tauchritz, Teichhalde, brown coal open-cast mine dump with deciduous afforestations six year-old, 51.065° N, 14.939° E, 7 May 1965, soil cores, 5–10 cm soil depth, leg. & det. WD (SMNG) 1 L5, 1 L8, 1 L9; [cf.] Görlitz, Kiesdorf, floodplain forest, 51.0391° N, 14.8838° E, 26 June 1962, soil cores, 0–5 cm soil depth, leg. & det. WD (SMNG) 1 L3, 1 L8.

Polypauropus duboscqi is a widely distributed species reported mainly from the southern half of Europe, but known also from Africa, USA, Argentina, Ceylon and Australia (Scheller 1973). The record of this species is listed in Guttmann (1979) as *Polypauropus* cf. *dubosqui* var. *inflatisetus*

Remy, 1938. The species is found in diverse grassland, arable land, degraded and ruderalised forests, dumps with ruderal vegetation cover and in a garden (Dizdarević 1971, 1975, Guttmann 1979, Scheller 1974, 1976). It occurs mostly in 28 to 55 cm depth of soil (Scheller 1973, 1974).

Family Amphipauropodidae

Amphipauropus rhenanus (Hüther, 1971)

Records. Between Rhine and Saar, surroundings of Bochum and Braunschweig [general information on collection sites for all species treated in this publication], 1955–1961 (Hüther 1974). **Rhineland-Palatinate**: Edesheim, vineyard, 11 February 1957, 9 April 1957, 16 May 1957, 30 August 1957, 25 October 1957, 22 November 1957, 20 December 1957, 4 March 1958 (Hüther 1971); Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982). **Baden-Württemberg**: Mannheim (Andersson et al. 2005, perhaps a misplacement of the type locality).

The species was described from Rhineland-Palatinate and subsequently found in Denmark, Norway and Sweden (Andersson et al. 2005). Hüther (1974) regarded it as markedly stenotopic and restricted to vineyards which were characterised by lessivé. It was found in soil from 0 to 50 cm. Later, Hüther (1982) recorded *A. rhenanus* from the Bausenberg, where the species was found on a dry meadow with a closed herb layer and a dense stock of *Echium vulgare* and *Rosa canina*. The soil was very loose and gravel-like. In Scandinavia the species was found in sandy soils at the seashore. This species might be synonymous with the insufficiently described *Amphipauropus mosellus* (Remy, 1960).

Family Brachypauropodidae

Brachypauropus hamiger Latzel, 1884

Previous Records. **Baden-Württemberg**: Triberg im Schwarzwald, Prisenhäusle, under rotting planks, VI.1936 (Remy 1936a). **Bavaria**: Rosenheim, Reschmühlbach-Stausee, 17 June 2005 (Spelda 2005).

New Records. **Saxony**: [cf.] Görlitz, Hirschfelde, Neisse Valley, deciduous forest, 50.9896° N, 14.9172° E, 30 June 1961, leg. & det. WD (SMNG) 1 ind.

This rare species is not known outside of Southern Europe (Scheller 1977a). It was recorded by Remy (1936a) for the first time for Germany when described as *B. tuberosus* from Triberg (Black Forest). It was later synonymized by Scheller (1976). *B. hamiger* is a woodland species which mostly occurs in beech woods, but also in coniferous forests (Rafalski 1977, Dizdarević 1971, 1977, Gisin, 1947) and moist localities, as under stones and under peat moss (Latzel 1884) or under rotting planks (Remy 1936a).The record from Bavaria was from a forested slope in waterlogged soil.

Brachypauropus strebeli Hüther, 1971

Records. **Rhineland-Palatinate**: Gau-Algesheim, Gau-Algesheimer Kopf, deciduous forest, 11 November 1955 (Hüther 1971); Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

This species has only been recorded from Germany. Hüther (1982) found *B. strebeli* in a dry meadow with very loose, gravel-like, partly uncovered soil or with *Rosa* and *Sarothamnus scoparius* and a dry deciduous forest in a vineyard region (Hüther 1971).

Family Eurypauropodidae

Trachypauropus cordatus (Scheller, 1974)
(Figs 2–3)

Previous Record. **North Rhine-Westphalia**: [cf.] Leverkusen, Gronenborn, NSG Gronenborner Teiche, 2005–2011 (Hüther & Kinkler 2013).

New Records. **Bavaria**: München-Feldmoching, 48.218° N, 11.5212° E, 3 October 2009, leg. J. Kapfenberger, det. JS (ZSM) 1 ♀. **Hesse**: Bürgel, Kuhmühlgraben, 50.1096° N, 8.7908° E, 4 February 2014, substrate sampling, leg. AA, det. UB (SMF) 1 L8, 1 L9; Eschborn, Westerbach, 50.1367° N, 8.5771° E, 6 February 2014, substrate sampling, leg. AA, det. UB (SMF) 1 L9; Laubach, Hirtenbach, border of a wood, 50.5461° N, 9.0088° E, 27 April 2014, substrate sampling, leg. AA, det. UB (SMF) 1 L8; Laubach, Hirtenbach, bridge Lange Hohl, river bank in a open site, linden tree avenue, under grass at bridge wall, 50.5438° N, 9.0100° E, 27 July 2014, substrate sampling, leg. AA, det. UB (SMF) 1 L8; Laubach, Schellenbach, river bank, open site, big oak, no *Impatiens*, under grass at bridge wall, 50.5438° N, 9.0101° E, 7 September 2014, substrate sampling, leg. AA, det. UB (SMF) 1 L6. **North Rhine-Westphalia**: Overath, Immekeppel, Immekeppel pond, 50.9589° N, 7.2407° E, 18 April 2014, substrate sampling, leg. AA, det. UB (SMF) 1 ♀; Overath, Immekeppel pond, Sülz, bridge wall, *Acer pseudoplatanus*, hornbeam, *Impatiens glandulifera*, 50.9587° N, 7.2390° E, 30 August 2014, substrate sampling, leg. AA, det. UB (SMF, SMNG) 44 ind.

The species has a subcosmopolitan distribution (Scheller 1982). In Germany it has been found nine times so far. Hüther & Kinkler (2013) recorded it (as *T.* cf. *cordatus*) in the nature protection area "Gronenborner Teiche", at the edge of a meadow overgrown with shrubs (*Rubus*), grass and herbs, and which was waterlogged after rain. All new material was identified according to the detailed description of *T. cordatus* by Scheller (1974a, 1977b) and the related species by Hasenhütl (1984, 1985, 1986, 1987).

It is known from literature that this species lives in deciduous forests (maple forest, under *Arbutus*) in Greece as well as under *Cypressus*, where it can be found in the soil and litter (Scheller 1974a, 1977b). In Spain Scheller (1974a) collected it from fern stems. All records, including the

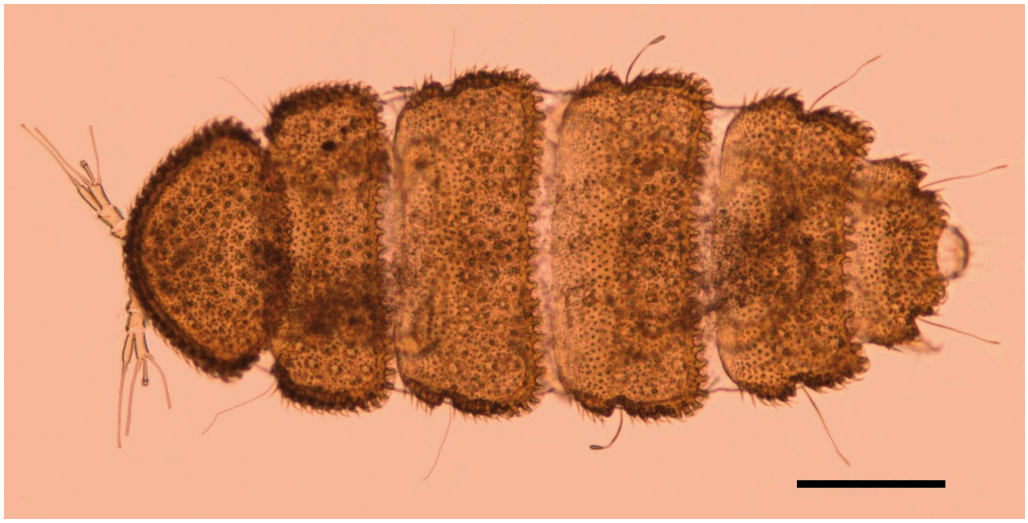


Fig. 3. Dorsal view (photo montage, SMNG) of *Trachypauropus cordatus* (Scheller, 1974) from Eschborn, Hesse. Scale bar – 200 µm.

new ones, indicate that *T. cordatus* prefers humid to wet habitats, where the species is found under litter and grass, in dead wood and in soil.

Acopauropus asper (Scheller, 1974)

Record. **Hesse**: Wiesbaden, Adamstal, from ground water filtration, 11 August 1964 (Scheller 1974).

Outside of Germany this species has only been recorded from Switzerland (Scheller 1976).

Acopauropus ornatus (Latzel, 1884)
(Figs. 2, 4–5)

First record. **Bavaria**: Törwang, Samerberg, WSW Mittelstation of Hochriesbahn, 900–930 m, 47.7601° N, 12.2378° E, 8 October 2014, leg. & det. JS (JSC) 2 ad., 2 ♂, 1 ♀, 2 juv.

The known distribution of *A. ornatus* was previously restricted to Austria, Bohemia, Italy and France. As shown by Hasenhütl (1985) this ornamental species was already known from the Austrian Salzach valley not far from the German border. The species was redescribed by Hasenhütl (1987). *A. ornatus* is a very rare woodland species, which is rarely found in dry places, e.g. in a quarry or in a garden (Latzel 1884, Remy 1946, Schuster 1960, Chalupský 1967, Hasenhütl 1985). The Bavarian series was collected in a *Picea abies* forest under logs with black rotting.

Nomina nuda

The following four species are given in Hüther (1982) for the Bausenberg area (dry meadows, dry coppice) but without any description or diagnostic characters. All are listed as nomina nuda in Scheller (2008).

***Decapauropus cursor* Hüther, 1982**

Record. **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982); Rheintal (Hüther 1982).

***Decapauropus trichosphaera* Hüther, 1982**

Record. **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

***Decapauropus unicus* Hüther, 1982**

Record. **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

***Fagepauropus breviseta* Hüther, 1982** (not *A. brevisetus* Silvestri, 1902)

Record. **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

Class Symphyla

Family Scolopendrellidae

Symphylella elongata Scheller, 1952

Previous Records. **Baden-Württemberg**: Endingen am Kaiserstuhl, Katharinaberg, 25 April 1961 (Scheller 1962). **Berlin**: Berlin-Zehlendorf, Grunewald, NSG Langes Luch, 1972–1974 (Haupt 1977).

New Records. **Baden-Württemberg**: Crailsheim, Heldenmühle, 49.1509° N, 10.0625° E, 19 April 1997, substrate sampling, leg. & det. JS (JSC) 1 ♀, 1 juv.; Lauda-Königshofen, Frauenberg, 49.5373° N, 9.7146° E, 3 April 1997, substrate

Fig. 4. Living specimen of *Acopauropus ornatus* (Latzel, 1884) from Hochries, Bavaria. Photo by J. Spelda.

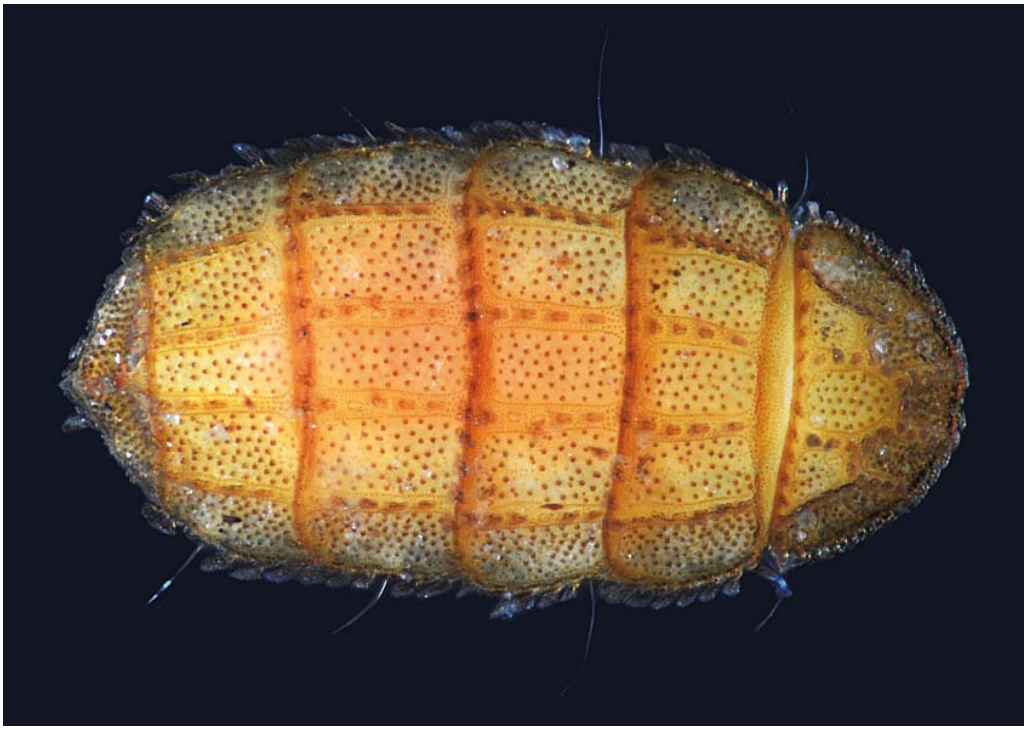


Fig. 5. Dorsal view (photo montage, ZSM) of *Acopauropus ornatus* (Latzel, 1884) from Hochries, Bavaria.

sampling, leg. & det. JS (JSC) 1 juv.; Altlußheim, 49.3071° N, 8.4834° E, 8 April 2010, hand sampling, leg. & det. JS (ZSM), 1 juv. **North Rhine-Westphalia**: [cf.] Langerscheid, spruce forest, 50.52131° N, 6.34056° E, 7 May 2014, leg. SMNG, soil core, 0–5 cm, det. UB (SMNG).

The species has not yet been found outside Europe (Scheller 1968). Some records from Corsica (Hirschenberger 1953), Menorca (Jubertie-Jupeau 1961) and the eastern Pyrenees (Rochaix 1954) are doubtful (Scheller 1968). Scheller (1952) described the type locality in South Sweden (Fågelsång, Scania) in great detail: at a depth of 5 cm on the underside of a stone, which was partly embedded in a well-moistened mould-soil on a beech-covered slope against above a brook. The ground was nearly bare, with sparse *Mercurialis perennis* and *Galeobdolon luteum*. In Germany the species was found in an alder swamp forest (Haupt 1977). Scheller (1962) has not specified the biotope type of his German records. In the Dinaric Alps the species lives mostly in woodland (Dizdarević 1971, 1975) between 50 and 1550 m a. s. l. In France the species was found in a ravine surrounded by macchia near a road on a morainic slope, beside *Rhododendron* heath, and in Spain in a lush pasture (Scheller 1973). In Austria it is recorded by the same author from a heap of manure in a garden (Scheller 1968). *S. elongata* is mostly found under stones, at different depths up to 60 cm, but not in the upper layer (0 to10 cm; Scheller 1968, 1973, Dizdarević 1971). Leinaas (1974) recorded the species in Norwegian coniferous forests mostly at a depth between 6 and 9 cm.

Symphylella isabellae (Grassi, 1886)

Previous Records. **Baden-Württemberg**: Tübingen, Bebenhausen, spruce forest, after windthrows, cleared, newly planted deciduous trees, 1996 (Krauß et al. 1998, JSC); Tübingen, Bebenhausen, spruce forest, after windthrows, cleared, 1996 (Krauß et al. 1998, JSC); Tübingen, Bebenhausen, spruce forest, after windthrows, not cleared, natural regeneration, 1996 (Krauß et al. 1998, see also Spelda 2005, JSC); Tübingen, Bebenhausen, spruce forest/beech forest, 1996 (Krauß et al. 1998, JSC); Bad Waldsee, spruce forest, 1996 (Krauß et al. 1998, see also Spelda 2005, JSC); Bad Waldsee, Durlesbach, Röschenwald, 29 October 1996 (Spelda 2005); Schelklingen, Sotzenhausen, 4 August 1993 (Spelda 2005); Dotternhausen, Plettenberg, Pyrola-Piceetum, 1 August 1998 (Spelda 2005); Welzheim-Rudersberg, forest, 7 May 1997 (Spelda 2005). **Bavaria**: Freising, Eichenfeld, Plantage, 3 July 2005 (Spelda 2005). **Lower Saxony**: Göttingen (Hüther 1982); Wolfenbüttel (Hüther 1982). **Saxony**: Leipzig, between Gundorf and Schkeuditz, Fraxino-Ulmetum, floodplain forest (Dunger 1967).

New Records. **Baden-Württemberg**: Rheinfelden, Hagenbacher Wald, 47.6033° N, 7.7293° E, 16 June 1998, substrate sampling, leg. LFU Baden-Württemberg, det. JS (JSC). **Hesse**: Wörsdorf, Henriettenthal, Wörsbach, under leaf litter, 50.2582° N, 8.2459° E, 9 June 1987, leg. AA, det. UB (SMF) 1 L10. **North Rhine-Westphalia**: Langerscheid, spruce forest, 50.52131° N, 6.34056° E, 7 May 2014, leg. SMNG, soil core, 0–5 cm, det. UB (SMNG) 1 ♂, 1 ♀, 1 L10. **Saxony**: Gröditz (Weißenberg), Gröditzer Skala, deciduous forest, near little creek, 51.2075° N, 14.63857° E, 20 May 2012, soil corer, Berlese Tullgren funnel, leg. PD & UB, det. UB (SMNG) 1 L10; Lückendorf, Steinigter Weg, spruce forest, 50.82627° N, 14.79255° E, 1 May 2012, soil corer, Berlese Tullgren funnel, leg. & det. UB (SMNG) 1 subad.

This species is known from Europe and Madagascar, the records from California (USA) being doubtful (Scheller 1973). *S. isabellae* seems to be a typical woodland species and is most commonly found in many forest associations, such as Fraxino-Ulmetum, Querco-Carpinetum, Abieti-Fagetum (Gisin 1949, Dunger 1968, Dizdarević 1971, Hüther 1982). Records from pastures or meadows are rather rare (Dizdarević 1971, Gisin 1949). Scheller (1973) found the species in a ravine surrounded by macchia. Occurrences in caves are known from France (Strinati 1969). This species was found under stones and in leaf litter (Scheller 1973, Juberthie-Jupeau & Tabacaru 1967).

Symphylella major Scheller, 1961

Record. **Baden-Württemberg**: Niederstotzingen, Vogelherdhöhle, cave, 1966 (Dobat 1975).

Symphylella major is a true mountain species, since the localities hitherto known are all situated in the mountains from 480 to 2400 m a. s. l. (Scheller 1968). Occurrences in caves are known from Switzerland (Scheller 1961), Slovakia (Kováč et al. 2014) and Germany (Dobat 1975). In the caves the species was collected in a very moist layer of clay deep within the cave (Scheller 1961, Dobat 1975), in Čertova diera in a passage with dark humic sediment (Kováč et al. 2014). In the Alps it was found by Scheller (1968) under stones surrounded by moss lying next to a melting snow patch.

Symphylella vulgaris (Hansen, 1903)

Previous Records. **Baden-Württemberg**: Bad Griesbach im Schwarzwald, 24 February 1936 (Remy 1943); Tübingen (Hansen 1903); Tübingen, Bebenhausen, spruce forest, on uncleared windthrow gaps, 1996 (Krauß et al. 1998, JSC); Bad Waldsee, spruce and beech forest, 1996 (Krauß et al. 1998, JSC). **Bavaria**: Flintsbach am Inn, forest at parking area near Falkenstein, 7 August 2004 (Spelda 2005); Freising, Eichenfeld, Plantage, 3 July 2005 (Spelda 2005); Pfaffenhofen, Scheyern, Scheyernforst, 9 November 2000 (Spelda 2005). **Berlin**: Berlin, Berlin-Dahlem Botanical Garden, greenhouses, 2000 (Scheller 2002); Berlin-Zehlendorf, Grunewald, NSG Langes Luch, 1972–1974 (Haupt 1977); **Brandenburg**: Schwedt, Oder valley, Lunow-Stolper Polder, dyked land, hardwood alluvial forest, 27 October 1993 – 22 October 1996 (Zerm 1996, 1997, 1999); Schwedt, Oder valley, Lunow-Stolper Polder, dyked land, hay meadow, 27 October 1993 – 22 October 1996 (Zerm 1996, 1997, 1999). **Hesse**: Marburg (Hansen 1903). **North Rhine-Westphalia**: Leverkusen, Gronenborn, NSG Gronenborner Teiche, 2005–2011 (Hüther & Kinkler 2013); Wesseling-Keldenich, Dikopshof, arable land, 1952–1953 (Herbke 1962); Kierspe, Hülloch, cave, 1932 (Griepenburg 1939, Lengersdorf 1961, Weber 1991). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982). **Saarland**: Wadgassen, mine heap, *Robinia* afforestation, 1975–1976 (Guttmann 1979). **Saxony**: Leipzig, Böhlen, brown coal mine, heap, poplar/black alder afforestation, 1960–1963 (Dunger 1968); Görlitz, Berzdorf-Tauchritz, Langteichhalde, brown coal open-cast mine dump with deciduous afforestations 24 year-old, 51.065° N, 14.932° E, pitfall traps, leg. & det. WD, teste UB (SMNG, Dunger 1966, 1968) 6 July 1976, 1 ind.; 27 July 1976, 1 ind.; 20 July 1976, 1 ind.; 29 June 1976, ind.; Görlitz, Kiesdorf, floodplain forest, 1960–1963 (Dunger 1968, see also Dunger 1966, b); Leipzig, between Gundorf and Schkeuditz, *Fraxino-Ulmetum*, floodplain forest, 1955–1956 (Dunger 1958, see also Dunger 1967).

New Records. **Baden-Württemberg**: Crailsheim, Heldenmühle, 49.1509° N, 10.0625° E, 19 April 1997, substrate sampling, leg. & det. JS (JSC) 1 juv.; Hüfingen, Schächer, Fürstenberg, 47.8886° N, 8.5764° E, 16 April 1993, flotation process, leg. & det. JS (JSC) 7 juv.; Reichertshausen 4 km WSW Möckmühl, 49.3117° N, 9.3097° E, 4 April 1997, hand sampling, leg. & det. JS (JSC) 1 juv.; Riesbürg, Goldberg, 48.8628° N, 10.4244° E, 9 April 1997, substrate sampling, leg. & det. JS (JSC) 1 ♀, 2 juv.; Schelklingen, Sotzenhausen, 48.3726° N, 9.7586° E, 4 August 1993, substrate sampling, leg. & det. JS (JSC); Tengen, Talheim, Riedbachtal, 47.8115° N, 8.6491° E, 29 May 1997, substrate sampling, leg. & det. JS (JSC) 2 ♀, 1 juv. ♀, 2 juv.; Waiblingen, Hegnach, Hart, 48.8558° N, 9.2878° E, 14 January 1989, hand sampling, leg. & det. JS (JSC). **Bavaria**: Jesenwang, Wildmoos, oak forest, 48,16201° N, 11,11067° E, 19 September 2012, soil corer, High-Gradient-Extractor (modified), leg. & det. UB (SMNG) 1 subad.; Jetzendorf, ropes course, 48.4405° N, 11.4201° E, 14 July 2013, flotation process, leg. & det. JS (ZSM) 2 ♀; Petershausen, 48.406° N, 11.4804° E, 28 July 2013 (ZSM) 1 ♀; Petershausen, Wendelstein, 11.4804° N, 48.4058° E, 20 July 2013, flotation process, leg. & det. JS (ZSM) 1 ♀; Kochel am See, Kesselberg, 11.3559° N, 47.6336° E, 21 July 2013, flotation process, leg. & det. JS (ZSM) 1 ♂. **Hesse**: Weilmünster, Lützendorf, bridge over the Weil, bridge wall, 50.4442° N, 8.3631° E, 30 May 1987, leg. AA, det. UB (SMF) 1 L12; Ober-Mörlen, Maiberg, at the bridge over the Usa, 50.3676° N, 8.6729° E, 4 June 1987, leg. AA, det. UB (SMF) 2 L12; Wetzlar, Hermannstein, Blasbach, under highway bridge, at the bridge, 50.5950° N, 8.4998° E, 6 June 1987, leg. AA, det. UB (SMF) 1 L12, 1 L10; Wetzlar, tributary brook 3 km north of Blasbach, 50.6301° N, 8.5135° E, 6 June 1987, leg. AA, det. UB (SMF) 1 L11; Schöffengrund, bank on the Wetzbach near Streichs-Mühle, 50.4995° N, 8.491° E, 27 June 1987, det. UB (SMF) 1 L10; Babenhausen, Hergershausen, Gersprenz, Langfelds-Mühle, bridge, 49.9439° N, 8.90268° E, 2 August 1987, leg. AA, det. UB (SMF) 2 L10. **Saxony**: Königshain, granite quarry nature trail, 51.19303° N, 14.84466° E, 5 April 2010, substrate sampling, leg. & det. UB (SMNG); Waltersdorf, parking area, on concrete traffic island, 50.85943° N, 14.654696° E, 28 April 2012, soil corer, Berlese Tullgren funnel, leg. & det. UB (SMNG).

This cosmopolitan species is one of the most common and widespread species of Symphyla in Central Europe. *S. vulgaris* is very eurytopic and occurs in forests as well as different meadow associations, suburban areas, caves, vineyards and any other biotopes (Gisin 1949, Scheller 1954, Dumitrescu & Orghidan 1969, Loksa 1966, Juberthie-Jupeau & Tabacaru 1968, Dizdarević

1975). It is one of the few symphylan species which also occur in arable land (Hüther 1982). In afforested dumps of an open cast coal mining area (Berzdorf/Germany) the species prefers the middle developmental stages and avoids the closed forest (Dunger 1968). In high mountains (Alps, Dinaric Alps) the species reaches above the timberline between up to 2300 and 2400 m a. s. l. (Gisin 1949, Dizdarević 1971). Intensive investigations on the ecology of this species (Dizdarević 1967, 1971, 1975) show that *S. vulgaris* occurs on all types of substrates (limestone, dolomite, serpentine, silicate), in all types of soil (syrosem, rendzina, rancer, brown, limestone, lessivé), and in 30 of 34 investigated plant communities. Densities are greater on northern slopes than on southern slopes. Seasonal vertical migrations are pronounced. It occurs under stones, in leaf litter, in dead wood and under moss (Bagnall 1914, Scheller 1954, Juberthie-Jupeau & Tabacaru 1968) and has even been recorded under large flowerpots (Scheller 1954). *S. vulgaris* occurs at all soil depths up to 60 cm with a preference of 10 to 30 cm (Dizdarević 1971).

S. vulgaris probably represents a species-group and needs a revision. Hüther observed nearly a dozen significantly differing forms in Central Europe, each of which May be a good species (Hüther & Kinkler 2013).

Scolopendrellopsis arvernorum (Ribaut, 1931)

Previous Records. **Baden-Württemberg**: Eberbach, Gammelsbach, 1 April 1997 (Spelda 2005); Crailsheim, Heldenmühle, 19 April 1997 (Spelda 2005); Schwäbisch Hall, Ruine Limpurg, 18 May 1997 (Spelda 2005). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

New Record. **Bavaria**: Pfaffenhofen, Scheyern, Scheyernforst, 48.4912° N, 11.4418° E, 9 November 2000, Berlese-funnel, leg. L. Beck, J. Römbke, J. Spelda et al., det. JS (JSC) 1 juv.

Scolopendrellopsis arvernorum is known from France, Great Britain and Italy. It was recorded in Germany by Hüther (1982) in a coppice (dominated by *Quercus* and *Carpinus*) at the Bausenberg and was subsequently recorded from southern Germany (Baden-Württemberg, Bavaria). The species was mainly found in forests, often on calcareous soil, and on a waste land (Remy 1961b, Hüther 1982).

Scolopendrellopsis subnuda (Hansen, 1904)

Previous Records. **Baden-Württemberg**: Triberg im Schwarzwald, 2 June 1936 (Remy 1943); Tübingen, Bebenhausen, spruce forest, after windthrows, cleared, newly planted deciduous trees, 1996–1996 (Krauß et al. 1998, JSC); Tübingen, Bebenhausen, spruce forest, after windthrows, cleared, 1996 (Krauß et al. 1998, JSC); Tübingen, Bebenhausen, spruce forest, after windthrows, not cleared, natural regeneration, 1996 (Krauß et al. 1998, JSC); Endingen am Kaiserstuhl, Katharinaberg, 25 April 1961 (Scheller 1962); Schelingen, beech forest, 23 April 1961 (Scheller 1962); Schelingen, Vogelsang, deciduous forest, 23 April 1961 (Scheller 1962); Konstanz, Mainau (Hüther 1982). **Bavaria**: Weissenburg, Laubenthal, 25 June 2005 (Spelda 2005); Rosenheim, Reschmühlbachstausee, 17 June 2005 (Spelda 2005); Pfaffenhofen, Scheyern, Scheyernforst, 9 November 2000 (Spelda 2005). **Berlin**: Berlin-Zehlendorf, Grunewald, NSG Langes Luch, 1972–1974 (Haupt 1977). **Hesse**: Marburg (Hansen 1903). **North Rhine-Westphalia**: Wesseling-Keldenich, Dikopshof, arable land, 1952–1953 (Herbke 1962); **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982). **Saarland**: Wadgassen, mine heap, *Robinia* afforestation, 1975–1976 (Guttmann 1979). **Saxony**: Berzdorf-Tauchritz, Langteichhalde, brown coal open-cast mine dump with deciduous afforestations 13 year-old, 51.065° N, 14.932° E, 30 April 1965, soil core, 0–10 cm, leg. & det. WD (SMNG, Dunger 1966, 1968,) 1 L9; Leipzig, Böhlen, brown coal mine, heap, poplar/black alder afforestation, 1960–1963 (Dunger 1968). **Thuringia**: Jena (Uhlmann 1940).

New Records. **Baden-Württemberg**: Lauda-Königshofen, Frauenberg, 49.5373° N, 9.7146° E, 3 April 1997, substrate sampling, leg. & det. JS (JSC) 1 ♀; Neuffen, Bäuerloch, 48.5501° N, 9.4001° E, 28 June 1997, substrate sampling, leg. & det. JS (JSC) 1 juv.; Rudersberg, Steinenberg, 48.8677° N, 9.5523° E, 7 May 1997, substrate sampling, leg. & det. JS (JSC) 1 juv. **Bavaria**: Rosenheim, Reschmühlbachstausee, 47.6317° N, 12.1589° E, 17 June 2005, flotation process, leg. & det. JS (ZSM) 1 juv. **Hesse**: Wetzlar, Blasbach, river bank, under grass and leaves, 50.5914° N, 8.5002° E, 6 June 1987, leg. AA, det. UB (SMF) 1 L12. **Mecklenburg-Western Pommerania**: Müritz National Park, Serrahner Berge,

beech forest, 53.3398° N, 13.2053° E, 16 October 2013, leg. SMNG, det. UB (SMNG) 1 L11. **North Rhine-Westphalia**: Langerscheid, spruce forest, 50.52131° N, 6.34056° E, 7 May 2014, leg. SMNG, soil core, 0–5 cm, det. UB (SMNG) 1 L9; Gemünd, oak forest, 50.5803° N, 6.5020° E, 7 May 2014, leg. SMNG, soil core, 0–5 cm, det. UB (SMNG) 1♂, 2 ♀, 2 L12, 2 L10, 1 L9; Gemünd, oak forest, leaf litter, 50.5803° N, 6.5020° E, 7 May 2014, leg. SMNG, det. UB (SMNG) 1 L12; Weiersheld, oak forest, 50.6263° N, 6.4154° E, 7 May 2014, leg. SMNG, soil core, 0–5 cm, det. UB (SMNG) 1 L11; Schlitterley, oak forest, 50.62028° N, 6.49382° E, 07 May 2014, leg. SMNG, soil core, 0–5 cm, det. UB (SMNG) 1 L11; Schlitterley, oak forest, leaf litter, 50.62028° N, 6.49382° E, 7 May 2014, leg. SMNG, det. UB (SMNG). **Saxony**: Ostritz, Neiße valley, Saupantsche, 50.97072° N, 14.90275° E, 28 October 2011, substrate sampling, leg. KV, det. UB (SMNG); Ostritz, parking area, bare ground with sparse *Veronica* sp., 51.0161° N, 14.9389° E, 17 April 2011, soil corer, Berlese Tullgren funnel, leg. & det. UB (SMNG) 1 subad.

Scolopendrellopsis subnuda is native to Europe and North Africa and introduced to Hawaii (Scheller 1968). It is widespread and mostly frequent. Hüther (1982) assumed that the species is probably parthenogenetic. The biotope spectrum of *S. subnuda* is broad and ranges from very wet localities such as floodplain forests and swamp forests (Franz et. al. 1959, Haupt 1977), through moist deciduous or mixed forests, dryer coniferous forests (Hansen 1903, Scheller 1962, Scheller 1954, Juberthie-Jupeau & Tabacaru 1968, Bagnall 1914, Dizdarević 1971, 1975, Dunger 1968, Guttmann 1979), to both fresh and dry grasslands and other open land types (Gisin 1949, Dizdarević 1971, Bagnall 1914, Scheller 1968). In Greece the species occurs in macchia (Scheller 1968). It was also found in gardens (Scheller 1968, Scheller 1954) and in a quarry (Bagnall 1914). Intensive investigations in the Dinaric Alps (Dizdarević 1967, 1971, 1975) showed that *S. subnuda* is found in all types of substrates (limestone, dolomite, serpentine, silicate), in all types of soil (syrosem, rendzina, rancer, brown, limestone, lessivé), and in 20 of 34 investigated plant communities. The densities are greater on southern than on northern slopes. Great seasonal differences in densities were found, the greatest being in spring and in autumn. The species occurs from 50 to 2300 m a. s. l. (Dizdarević 1971). *S. subnuda* was found to occur under stones (e.g. Scheller 1973, Juberthie-Jupeau & Tabacaru 1967) and in the upper soil layer up to 60 cm depth (Scheller 1973, Dizdarević 1971, Guttmann 1979). Bagnall (1914) found the species in Great Britain under stones on sea banks and under a deeply embedded stone in a large wood on the banks of the Wear.

Scolopendrella notacantha Gervais, 1844

Previous Records. **Baden-Württemberg**: Sigmaringen (Hüther 1982); Triberg im Schwarzwald (Remy & Hoffmann 1959); Oppenau, 25 February 1936 (Remy 1943); Bad Waldsee, spruce and beech forest, 1996 (Krauß et al. 1998, JSC); **Bavaria**: Weissenburg, Laubenthal, 25 June 2005 (Spelda 2005). **Hamburg**: Hamburg-Eilbek, Garten, 1894 (Latzel 1895). **North Rhine-Westphalia**: Eifel, southwest of Euskirchen (Hüther 1982). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976–September1979 (Hüther 1982); Zweibrücken (Hüther 1982). **Thuringia**: Jena, Pennickental, shrubs (Seifert 1953); Jena, Wöllmisse (Seifert 1953).

New Records. **Baden-Württemberg**: Bad Wurzach, Knobel, gravel-pit II, 47.9428° N, 9.8743° E, May 1991, substrate sampling, leg. D. Rothmund, det. JS (JSC); Blaubeuren, quarry Merkle, 48.3947° N, 9.8211° E, 13 April 1993, flotation process, leg. & det. JS (JSC); Hüfingen, Schächer, Fürstenberg, 47.8886° N, 8.5764° E, 16 April 1993, flotation process, leg. & det. JS (JSC) 1 ♀; Isny im Allgäu, Buchenstock, Luegensland, 47.6891° N, 10.0966° E, 27 August 1990, hand sampling, leg. & det. JS (JSC); Rheinfelden, Hagenbacher Wald, 47.6033° N, 7.7293° E, 16 June 1998, substrate sampling, leg. LFU Baden-Württemberg, det. JS (JSC); Schelklingen, Sotzenhausen, 48.3726° N, 9.7586° E, 4 August 1993, substrate sampling, leg. & det. JS (JSC); Stühlingen, 47.7361° N, 8.4491° E, 16 June 1998, substrate sampling, leg. LFU Baden-Württemberg, det. JS (JSC); Vöhrenbach, Linach-Stausee, marsh area, 48.0151° N, 8.3113° E, 16 April 1993, flotation process, leg. & det. JS (JSC) 11 ♂, 6 ♀. **Bavaria**: Kochel am See, Pessenbach, Pessenbach valley, 47.6791° N, 11.4011° E, 21 July 2013, flotation process, leg. & det. JS (ZSM) 1 juv.

Scolopendrella notacantha is a widely distributed species in the Palaearctic, with a distribution area ranging from England and Belgium to the Caucasus (Scheller 1973). It is most frequently recorded from forests, but also found in pastures of *Arrhenatherion elatioris* and in gardens or

recultivated quarries (e.g. Hüther 1982, Dizdarević 1971, Gisin 1949, Juberthie-Jupeau & Tabacaru 1967). This species occurs in moist places in leaf litter and under stones (Seifert 1953, Scheller 1973, Juberthie-Jupeau & Tabacaru 1967), but never in sandy soils (Seifert 1953).

Geophilella pyrenaica Ribaut, 1913

Records. **Baden-Württemberg**: Hüfingen, Schächer, Fürstenberg (Spelda 2005). **North Rhine-Westphalia**: Blankenheim, Alendorf (Hüther 1982). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

The species is restricted to the south-western Palaearctic region and is rarely found in Central Europe (Scheller 1973). In addition to occurrence in forest stands the species has mostly been recorded from various meadow associations (Dizdarević 1971, 1975, Gisin 1949), in Germany especially from dry meadows and the successional shrub stages. It was recorded also in alpine low tussock grassland up to 2300 m a. s. l. (Spanish Pyrenees, Scheller 1973). Its occurrence in Italian caves has been reported by Franciscolo (1955). The species is found at a soil depth between 10 and 30 cm, rarely down to 60 cm (Dizdarević 1971). It was also found under stones (Scheller 1973).

Family Scutigerellidae

Hanseniella nivea (Scopoli, 1763)

Previous Record. **Saxony**: Zwickau, Fraureuth, Gospersgrün, adit in Gospersgrüner Tal, Ziegelei (Büttner 1963).

New Records. **Saxony**: Deutsch-Paulsdorf, Spitzberg, deciduous forest (*Fraxinus excelsior*, *Fagus sylvatica*, *Carpinus betulus*), 330 m a. s. l., 51.0998° N, 14.8194° E, 17 September 2014, soil core, 0–5 cm, leg. SMNG, det. KV & UB (SMNG) 1 ♀ L12.

This species is widespread in Central and Southern Europe. It occurs mostly in forests, but also pastures and in steep and dry meadows up to 2200 m a. s. l. (e.g. Brölemann 1899, Loksa 1966, Dizdarević 1971, 1975). In Yugoslavia and Greece macchia is also inhabited (Scheller 1968). Records from caves exist for Germany (Büttner 1963) and Romania (Juberthie-Jupeau & Tabacaru 1967, Dumitrescu & Orghidan 1969). Gisin (1949) found it in Italy under willows in gravel.

Hanseniella oligomacrochaeta Scheller, 2002

Record. **Berlin**: Berlin-Dahlem Botanical Garden, greenhouses, 2000 (Scheller 2002).

Only known from the type locality in a greenhouse in Berlin.

Hanseniella orientalis (Hansen, 1903)

Record. **Berlin**: Berlin-Dahlem Botanical Garden, greenhouses, 2000 (Scheller 2002).

The species seems to be widespread in the tropics in Asia and America (Scheller 2002).

Scutigerella Ryder, 1882

The genus *Scutigerella* is very problematic. The original description of the type species *Scutigerella immaculata* is short with only few details (Newport 1845), the type material is lost, the type locality (St. John's Wood near London) destroyed (pers. comm. Scheller), and no redescription

was ever made. Prior to the revision of Michelbacher (1942) all specimens of *Scutigerella* have been assigned to this species. During his revision Michelbacher (1942) noticed it to host a species complex, but only adult specimens with completely differentiated penultimate scutum can be determined without doubt. Apart from six anamorphic stadia there are additional six moult stages in the epimorphic state, thus it is only possible for a small percentage of collected specimens to assign them to a certain species. All other specimens have to be labeled as *Scutigerella* sp. A critical examination showed that the German material represents two groups, which show a remarkable variation in the characters used by Michelbacher (1942) for the separation of the species. Group 1 shows only a slight emargination in the first scutum, thus the specimens have formally assigned to *S. causeyae*, as no specimen showed coxal sacs on leg pair 8, a character of *S. verhoeffi*. These specimens occur mostly, but not always in natural biotopes, such as forests. Group 2 represents the specimens with a deeper emargination of the first scutum, including *S. immaculata*, *S. nodicercus*, *S. palmonii* and *S. remyi*. Specimens of this group are often found in synanthropic biotopes, such as gardens or greenhouses.

Scutigerella causeyae Michelbacher, 1942

Previous Records. **Baden-Württemberg**: Schelingen, beech forest, 23 April 1961 (Scheller 1962). **Bavaria**: Wiesenttal, Neudorf, Schönsteinhöhle, cave, 1974–1975 (Plachter & Plachter 1988). **Berlin**: Berlin-Zehlendorf, Grunewald, NSG Langes Luch, 1972–1974 (Haupt 1976, 1977). **North Rhine-Westphalia**: Leverkusen, Gronenborn, NSG Gronenborner Teiche, 2005–2011 (Hüther & Kinkler 2013). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

New Records. **Baden-Württemberg**: Irndorf, Eichfelsen, 48.06356° N, 8.9926° E, 19 October 2013, sieving, leg. KV, det. UB (SMNG); Ludwigsburg, Fröbelstraße, hedge, 48.90546° N, 9.17905° E, 30 June 2013, substrate sampling, leg. & det. UB (SMNG); Ludwigsburg, garden compost heap, 48.910443° N, 9.173799° E, 24 June 2012, exhaustor, leg. & det. UB (SMNG); Ludwigsburg, garden, compost heap, 48.910443° N, 9.173799° E, 07 April 2011, substrate sampling, leg. & det. UB (SMNG); Ludwigsburg, Salonwald, 48.88711° N, 9.1994° E, 30 June 2013, substrate sampling, leg. & det. UB (SMNG) 1 subad.; Irndorf, Eichfelsen, deciduous forest with oak, beech and maple, slope edge to Donau, 48.0636° N, 8.9926° E, 19 October 2013, leg. KV, det. UB (SMNG); Fridingen an der Donau, Knopfmacherfelsen, 48.0301° N, 8.9504° E, 20 October 2013, leg. KV, det. UB (SMNG); Ratshausen, spruce forest, spring area with tall forbs, *Impatiens*, *Sambucus*, moss, 48.2036° N, 8.8176° E, 18 October 2013, leg. KV, det. UB (SMNG); Bubsheim, street to Egesheim, deciduous forest with beech, oak and maple, *Mercurialis perennis*, 48.1258° N, 8.8287° E, 20 October 2013, leg. KV, det. UB (SMNG). **Bavaria**: Kochel am See, Lainbach falls, 48.648° N, 11.3688° E, 30 August 2013, hand sampling, leg. & det. JS (ZSM) 1 ♀; Kochel am See, Kesselberg, 47.634° N, 11.3559° E, 21 July 2013, flotation process, leg. & det. JS (ZSM) 1 ♀; Jetzendorf, ropes course, 48.4405° N, 11.4201 ° E, 14 July 2013, flotation process, leg. & det. JS (ZSM) 1 ♂. **Hesse**: Nieder-Brechen, Emsbach, Berger Kirche, slope, 50.3625° N, 8.1481° E, 2 October 1987, leg. AA, det. UB (SMF) 1 L10; Hofheim, Burkhards-Mühle, dam at Schwarbach, 50.0924° N, 8,4318° E, 24 July 1987, leg. H. Nesemann, det. UB (SMF) 1 L12. **North Rhine-Westphalia**: Langerscheid, spruce forest, 50.52131° N, 6.34056° E, 7 May 2014, leg. SMNG, soil core, 0–5 cm, det. UB (SMNG) 1 L12; Dedenborn, spruce forest, 50.55002° N, 6.34147° E, 7 May 2014, leg. SMNG soil core, 0–5 cm, det. UB (SMNG) 2 ♀; Dedenborn, spruce forest, leaf litter, 50.55002° N, 6.34147° E, 7 May 2014, leg. SMNG, det. UB (SMNG) 1 L12; Erkensruhr, beech forest, leaf litter, 50.5698° N, 6.3601° E, 7 May 2014, leg. SMNG, det. UB (SMNG) 1 L11; Schlitterley, oak forest, 50.62028° N, 6.49382° E, 7 May 2014, leg. SMNG, soil core, 0–5 cm, det. UB (SMNG) 1 L12, 1 L11; Schlitterley, oak forest, leaf litter, 50.62028° N, 6.49382° E, 7 May 2014, leg. SMNG, det. UB (SMNG) 1 ♂, 1 L12, 1 L10. **Saxony**: Sohland am Rotstein, Rotstein, deciduous forest with basalt boulder, 51.10823° N, 14.76663° E, 13 May 2012, soil corer, Berlese Tullgren funnel, leg. UB & PD, det. UB (SMNG); Weißkollm, pine forest on sandy soil, leaf litter, 51.489° N, 14.383° E, 20 May 2014, leg. SMNG, det. UB (SMNG) 1 ♀.

Scutigerella causeyae is one of the most frequently occurring symphylan species in Central Europe (Hüther & Kinkler 2013), but this May be due to the fact that it is easily recognizable, due to its subtruncate second scutum. Nevertheless it is easily confused with *S. verhoeffi*, especially if the records originate from the Alps. The species lives at very different locations, such as on open lands, grassy slopes and other meadows, in stony scree material, in various wood and shrub lands and vineyards (Scheller 1962, 1968, Dizdarević 1971, Haupt 1977, Hüther 1982). The

record with the highest altitude was at 2500 m a. s. l. in front of a glacier with sparse vegetation (Scheller 1968).

Scutigerella immaculata (Newport, 1845)

Records. **Baden-Württemberg**: Bad Griesbach im Schwarzwald, 24–25 February 1936, 28 June 1936 (Remy 1943); Bad Urach, Eppenzillhöhle, cave, 29 June 1968 (Dobat 1975); Endingen am Kaiserstuhl, Katharinaberg, 25 April 1961 (Scheller 1962); Eschenbach (Württemberg), Luitpoldhöhle, cave (Dobat 1978); Freiburg, Schloßberg, 1 August 1936 (Remy 1943); Hausach, 2 June 1936 (Remy 1943); Schelingen, Badberg, south slope, 23 April 1961 (Scheller 1962); Tübingen, Spitzberg, 1958–1965 (Schmid 1966). **Bavaria**: Erlangen, bumblebee nest, 1940–1950 (Postner 1951a, b); Markt Nordheim, Höllern, cave (Dobat 1978); Garmisch-Partenkirchen, Partnachklamm, March–May 1900 (Verhoeff 1901). **Berlin**: Berlin-Zehlendorf, Grunewald, NSG Langes Luch (Haupt 1969, 1971). **Brandenburg**: Schwedt, Oder valley, Lunow-Stolper Polder, dyked land, hay meadow, 27 October 1993 – 22 October 1996 (Zerm 1996, 1997, 1999). **Hamburg**: Hamburg-Niendorf, 1894 (Latzel 1895); Hamburg, Bezirk Hamburg-Harburg, Harburger Berge, Haake, 1894 (Latzel 1895). **Hesse**: Marburg, 1904 (Ellingsen 1905); Marburg (Hansen 1903). **Lower Saxony**: Rosengarten, Sottorf, 1894 (Latzel 1895). **Mecklenburg-Western Pommerania**: [cf.] Ludwigslust, palace garden, 2005–2007 (Jueg 2009). **North Rhine-Westphalia**: Leverkusen, Gronenborn, NSG Gronenborner Teiche, 2005–2011 (Hüther & Kinkler 2013); Warstein, Bilsteinhöhle, cave, April 1929 (Griepenburg 1941, Lengersdorf 1961, Weber 1991); Schwelm, Brunnenstube Strickerberg „Pütt“, cave (Schubart 1938, Lengersdorf 1961, Weber 1991). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982). **Saxony**: Görlitz, Berzdorf, brown coal-cast mine dump with afforestation, 1960–1963 (Dunger 1968, see also 1966, 1967, 1969); Görlitz, Kiesdorf, floodplain forest, 51.0391° N, 14.8838° E, soil core, 0–5 cm and 5–10 cm soil depth, leg. & det. WD (SMNG, Dunger 1966, 1968) 13 August 1962, 1 L12; 14 May 1965, 2 L9, 1 L12; Erzgebirge, Kranichsee (Dunger 1967); Torgau, Dahlener Heide (Dunger 1967); Zwickau, Grünau (Langenweißbach), Grünauer Höhle, cave (Büttner 1963); Zwickau, Grünau (Langenweißbach), cave in marble quarry (Büttner 1926). **Schleswig-Holstein**: Aumühle-Friedrichsruh, Sachsenwald, 1894 (Latzel 1895). **Thuringia**: Jena (Uhlmann 1940).

The records of this species suggest a cosmopolitian distribution. It has been reported mainly from forests, although the species can also colonize meadows (e.g. Scheller 1954, Dizdarević 1971, 1975, Seifert 1953, Loksa 1966). Records from caves are also known (Pax 1936, Büttner 1963, Dobat 1975). Sufficient humidity seems to be an important pre-condition for *S. immaculata* (Friedel 1928). Bagnall (1914) found the species even at the seashore in Great Britain. Occasionally the species occurs in ant nests under stones (Evans 1907). Sometimes *S. immaculata* can be a pest in greenhouses (Michelbacher 1942, Scheller 1960). There is no altitude preferred by the species. It is known up to 1600 m a. s. l. *S. immaculata* can be found very frequently in leaf litter, under stones, in moss, on tree-stumps and under planks (e.g. Scheller 1954). Due to the doubtful status of *S. immaculata* all records and this ecological evaluation should be treated with caution.

Scutigerella linsleyi Michelbacher, 1942

Record. Southern Germany (Scheller, 1968).

Records of this species are very rare. It is known from the type locality in California (Michelbacher 1942), Italy, Germany (Scheller 1968), Bosnia and Herzegovina (Dizdarević 1971, 1975, Živadinović et al. 1967), and England (Edwards 1959b). At the type locality it was found in a loamy soil on a slope covered with rather dense brush (Michelbacher 1942). In England it was found in the upper layers of the soil in extremely large numbers causing considerable damage to the roots of cabbage plants. Dizdarievic (1971, 1975) and Živadinović et al. (1967) found *S. linsleyi* especially in forests (deciduous and coniferous forests), but also on semi-dry grassland and in *Molinio Arrhenateretea*.

Scutigerella nodicercus Michelbacher, 1942

Previous Records. **Baden-Württemberg**: along highway between Heidelberg and Karlsruhe, 29 April 1954 (Juberthie-Jupeau 1957); Schelingen, Vogelsang, deciduous forest, 23 April 1961 (Scheller 1962). **Bavaria**: Oberbayern

(Michelbacher 1942). **Rhineland-Palatinate**: [cf.] Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

New Records. **Baden-Württemberg**: Stuttgart, Zuffenhausen, Hummelgraben, garden, 48.8415° N, 9.1787° E, 12 August 2013, hand sampling, leg. & det. JS (ZSM) 1 ♂. **Bavaria**: Petershausen, Wendelstein, 48.4058° N, 11.4804° E, 20 July 2013, flotation process, leg. & det. JS (ZSM) 1 ♀.

Scutigerella nodicerus is distributed in Western and Central Europe. The species lives in Germany in woodland (beech and dryer woods of oak and hornbeam) and gardens (new records). Scheller (1962) quoted it from the Kaiserstuhl from "deciduous forest" without specification. Scheller (1973) found *S. nodicerus* in France in a ravine surrounded by macchia, but also in lush and steep pastures. In Spain he recorded it from a slate talus under *Buxus sempervirens* and in a lush pasture. The highest occurrence arises from the Dolomite Alps at 2000 m a. s. l. (Marcuzzi 1956). This species was found under stones and in soil cores (Hüther 1982, Scheller 1973).

S. nodicercus is very similar to *S. palmonii*. Hüther (1982) does not exclude synonymy with *S. remyi*.

Scutigerella palmonii Michelbacher, 1942

Records. **Baden-Württemberg**: Glems (Metzingen), Glemser Hölloch, cave, 20 January 1967 (Dobat 1975). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976 – September 1979 (Hüther 1982).

This species is also known from Palestine (type locality), Great Britain (Edwards 1959b), Italy and Austria (Hüther 1982). The species seems to be eurytopic. It occurs in woodland as well as in dry meadows, pastures and waste land (Hüther 1982). Dobat (1975) recorded it from a cave in the Swabian Alb (Glemser Hölloch).

Hüther (1982) assumed a species complex is hiding under this name.

Scutigerella remyi Juberthie-Jupeau, 1963

Records. **Bavaria**: Oberau, Moorloch, cave, 1974–1975 (Plachter & Plachter 1988). **North Rhine-Westphalia**: Leverkusen, Gronenborn, NSG Gronenborner Teiche, 2005–2011 (Hüther & Kinkler 2013). **Rhineland-Palatinate**: Niederzissen, Bausenberg, September 1976–September 1979 (Hüther 1982).

The species has not been reported from outside Europe. In the Austrian and Italian Alps the species was found by Scheller (1968) in different alpine biotopes up to 2500 m a. s. l., such as grass-heath, dry broom-heath, scrub-heath with dwarf pines, between dwarf-like pines near a stream and melting snow patches. At lower altitudes the species occurs in different forest types (Juberthie-Jupeau 1963, Hüther 1982). One time it was found in a cave in Austria (Scheller 1968). In the Spanish Pyrenees *S. remyi* was found in a lush pasture (Scheller 1973). Often found under stones, in leaf litter and in soil cores (Juberthie-Jupeau & Tabacaru 1967, Scheller 1973, Hüther 1982)
A clear separation from *S. nodicercus* is not always given (Hüther & Kinkler 2013).

Scutigerella verhoeffi Michelbacher, 1942

Records. "Probably from the Austrian Alps in Southern Germany" (Michelbacher 1942).

According to Michelbacher (1942) the holotype of the species comes "probably from the Austrian Alps in southern Germany. Four specimens were sent me by K. W. Verhoeff with a letter dated April 14, 1938. The label on the vial is poorly written, but examples are presumably from the locality above mentioned". The record of Würmli (1972) for Austria refers to this as well as the record of Schubart (1964) for Southern Germany (without details of the locations). Scheller (1968)

mistrusts the occurrence of this species in Austria. *S. verhoeffi* is also known from Switzerland (Gisin 1951), but also without any information on the locality. It is probably often admixed with *S. causeyae*.

DISCUSSION

The distributions of Pauropoda and Symphyla species are very insufficiently known. According to our study, currently altogether 36 species of Pauropoda and 18 species of Symphyla are known from Germany. Most of them are very widespread or even cosmopolitan species, and so far only *D. broelemanni*, *D. multiplex*, and *P. huxleyi* seem to be more restricted in range, but the German species are all found in various parts of the Western Palaearctic.

Due to their wide ranges, some of these 'species' have been suspected to host cryptic species complexes, and for uncovering those an integrated taxonomic approach should at best be applied, including molecular methods as well as additional morphological characters, and especially detailed data on distribution and habitat parameters.

Comprehensive ecological studies on Pauropoda and Symphyla are rare, and if information is available at all, it is mostly confined on mere habitat information. However, the investigations of Dizdarević (1967, 1971, 1975) provide a noteworthy counterexample.

Based on our review of the literature and our own sampling data most of the German symphylan species seem to be eurytopic (e.g., *S. causeyae*, *G. pyrenaica*) and do not avoid synanthropic localities like gardens or arable land (*S. subnuda*, *S. vulgaris* group). In contrast, *S. remyi* is also eurytopic, but did not occur in urban areas.

Many Symphyla species are usually found in woodland with some tendencies to also occupy open land such as meadows or pastures (e. g. *S. notacantha*, *S. immaculata*, *S. nodicercus*, *H. nivea*). *S. isabellae* seems to be a typical woodland species.

In some cases the sparse records with information on habitat data available did not allow any deduction of habitat preferences, e.g. for *S. arvernorum*, *S. verhoeffi* and *S. elongata.*

In contrast to symphylan species with a more or less broad range of possible habitats, pauropods seem to be more specific in their habitat requirements. About half of the German pauropods show more or less distinct preferences for a special habitat type. Woodland species are *S. pubescens*, *B. hamiger* and *A. ornatus*, while *A. danicus*, *D. hessei*, *P. furcifer*, *P. lanceolatus*, *S. pedunculatus*, *S. lyrifer*, *D. thalassophilus* and *D. tenellus* prefer forests to open land. *T. cordatus* May also be a woodland species with a preference for wet habitats, but currently there are too few records for a clear statement. However, Schuster's (1978) conclusion that Eurypauropodidae seem to avoid coniferous forests is not confirmed by the new records of *A. ornatus*. In general pauropods are rare in coniferous forests in Northern Europe with low pH-values and low average temperatures, whereas in coniferous forests in Central and South Europe on limestone and with higher average temperatures pauropods are more numerous.

Only two taxa seem to be restricted to open land (*D. gracilis amaudruti* and *D. helveticus obtusicornis*), while for *B. strebeli* a clear pattern cannot be derived. *D. viticolus* and *A. rhenanus* are stenotopic in vineyards according to Hüther (1982).

Among the pauropods there are also some species that frequently or exclusively occur in human-influenced or disturbed habitats (*D. distinctus*, *D. gracilis sequanus, P. duboscqi*).

Some species (*D. cuenoti*, *D. gracilis*, *D. helveticus*, *D. barcinonensis*, *D. helophorus*, *D. multiplex*, *D. vulgaris*, *P. huxleyi*) are very probably also eurytopic.

For a number of other species the ecological preferences are unclear due to lack of records (*D. aristatus, D. doryphorus, D. kocheri, D. meridianus, P. bagnalli, S. pedunculatus* var. *brevicornis* and *A. asper*).

Symphyla and Pauropoda, especially woodland species, are often found in caves or mines under moist and cool conditions. So far, the following species are known from German caves: *S. causeyae*, *S. immaculata*, *S. vulgaris*, *S. major*, *S. palmonii*, *H. nivea, A. danicus*, *P. lanceolatus*, *P. huxleyi* and *S. pedunculatus*.

From caves outside of Germany the following species are known: *G. pyrenaica*, *S. isabellae*, *S. vulgaris, S. remyi*, *P. furcifer*, *D. barcinonensis*, *D. gracilis* and *S. pedunculatus* s. str.

Vegetation cover and structure of the soil are the main factors affecting the distribution of Symphyla and Pauropoda. Which of these ecological factors has greater significance varies for each species (Dizdarević 1971).

Michelbacher (1949) and Starling (1944) stated that Symphyla and Pauropoda are found in all types of soils, but most of them prefer loamy and cohesive soils. Only in exceptional cases sandy soils can also be colonized (*D. gracilis*, *D. helveticus*). Edwards (1958) emphasized that sandy soils are least favourable for symphylans.

Special investigations about the preferred soil depth of Symphyla and Pauropoda are very rare (Salt et al. 1948, Michelbacher 1949, Edwards 1958, 1961, Leinaas 1974). Dizdarević (1971), who investigated many pauropod and symphylan species, stated that the majority of species are not confined to a definitive layer of soil. By reviewing all data available it can be seen that some species, e.g. *S. subnuda* and *S. elongata,* occupy all soil horizons up to 50 or 60 cm, while other species prefer soil depths between 10 and 30 cm (*S. vulgaris* and *G. pyrenaica*). Why Symphyla prefer the deeper soil layers of the mineral horizon is not known but one factor might be the well-buffered temperatures in deeper layers. Apart from other factors such as temperature, food resources, or life cycle, there is probably a certain dependency on the relative soil or air humidity, which causes a seasonal vertical migration (Edwards 1961). Such migrations were investigated by Michelbacher (1930, California), Sawa (1930, Japan), Belfield (1956, Great Britain) and Edwards (1961, Great Britain). There is a positive correlation between soil moisture content, relative humidity (preferably 100%) and the occurrence of Symphyla. In spring and early summer *S. immaculata* and *S. vulgaris* migrate in high numbers to the soil surface. In warm summer periods, when the upper soil dries out, the populations withdraw to deeper soil layers, and in autumn a smaller number compared to spring abundances migrate to the soil surface (Edwards 1959c).

For Pauropoda information about preferred soil depths for different species is even rarer than for Symphyla. The literature data indicates that most pauropod species prefer upper soil layers (*D. vulgaris*, *P. lanceolatus*, *P. furcifer*) but May occur down to 60 cm depth. *D. gracilis* and *D. cuenoti* live in deeper soil layers, and are mostly found at depths between 15 and 30 cm. The deepest records for these species are from 70 cm, 75 cm and 80 cm respectively (Scheller 1974, Hågvar 1997).

Dizdarević (1971) could show that each species has a special seasonal dynamic, reaching maximum and minimum density in different months.

The conclusions given here summarise our current knowledge of the taxonomy, distribution and habitat preferences of Symphyla and Pauropoda in Germany, which without doubt is far from being comprehensive. As such, our conclusions are to be taken with some caution, as future research, when applying a more integrated eco-taxonomic approach as mentioned above, will not only deepen our knowledge on both classes but surely also resolve some topics of symphylan and pauropod biology that today still remain enigmatic or ambiguous.

Acknowledgements

We thank Andreas Allspach (SMF), Ludwig Beck (Karlsruhe), the late Heiko Bellmann (Ulm) and Jannis Kapfenberger (Munich) who provided sampling material and information on localities, Franziska Meier (Karlsruhe) and Thomas Stierhof (Karlsruhe) for sorting of material, Marlies Wiesenhütter (SMNG) for literature search and data input and Bob Mesibov

(Tasmania) for suggestions on improving the English text. Special thanks to Ulf Scheller (Häggeboholm) not only for valuable suggestions for the manuscript but also for advice to JS during the 8th International Congress of Myriapodology in Innsbruck how to find pauropods.

REFERENCES

Andersson G., Meidell B. A., Scheller U., Djursvoll P., Budd G. & Gärdenfors U. 2005: *Mångfotingar Myriapoda.* Uppsalla: ArtDatabanken, SLU, 351 pp.

Bagnall R. 1914: A synopsis of the British Symphyla, with descriptions of new species. *Transactions of the Natural History Society of Northumberland* **4**: 17–41.

Belfield W. 1956: The Arthropoda of the Soil in a West African Pasture. *Journal of Animal Ecology* **25**: 275–287.

Büttner K. 1926: Die Stollen, Bergwerke und Höhlen in der Umgebung von Zwickau und ihre Tierwelt. *Jahresbericht des Vereins für Naturkunde* **26**: 12–33.

Büttner K. 1963: Beitrag zur Kenntnis der Verbreitung der Diplopoden, Symphylen und Chilopoden in Westsachsen. *Abhandlungen und Berichte des Naturkundemuseums Görlitz* **38**(4): 1–7.

Burkhardt U., Russell D. J., Decker P., Döhler M., Höfer H., Lesch S., Rick S., Römbke J., Trog C., Vorwald J., Wurst E. & Xylander W. E. R. 2014: The Edaphobase Project of GBIF-Germany – A new online soil-zoological data warehouse. *Applied Soil Ecology* **83**: 3–12.

Chalupský J. 1961: Note on the occurence of the Pauropoda in Bohemia. *Věstník Československé Společnosti Zoologické* **25**: 142–146.

Chalupský J. 1967: Bohemian Pauropoda III. *Věstník Československé Společnosti Zoologické* **31**: 121–131.

Dizdarević M. 1967: Prilog ekologiji vrsta Symphylella vulgaris Hansen i Symphellopsis subnuda Hansen [Contribution to the ecology of Symphylella vulgaris Hansen and Symphellopsis subnuda Hansen]. *Godišnjak Biološkog Instituta Univerziteta u Sarajevu* **20**: 17–24 (in Bosnian).

Dizdarević M. 1971: Distribucija, stratifikacija i sezonska dinamika populacija vrsta Symphyla i Pauropoda [Distribution, stratification and seasonal population dynamics of the species Symphyla and Pauropoda]. *Godišnjak Biološkog Instituta Univerziteta u Sarajevu* **24**: 29–103 (in Bosnian).

Dizdarević M. 1973: Fauna symphyla i pauropoda u Bosni i Hercegovini [Fauna of Symphyla and Pauropoda in Bosnia and Herzegovina]. *Radovi* **46**: 245–272 (in Bosnian, with an abstract in English).

Dizdarević M. 1975: Symphyla i Pauropoda kao komponenta biocenoza kraskih polja u podrucju dinarida [Symphyla and Pauropoda as component of the biocenose of karstic poljes in the region of the Dinards]. *Godišnjak Biološkog Instituta Univerziteta u Sarajevu* **28**: 65–81 (in Bosnian).

Dizdarević M. 1977: Distribucija i dinamika gustine populacija nekih vrsta symphyla i pauropoda u ekosistemima Jahorine [Distribution and population dynamics of some species Symphyla and Pauropoda in the ecosystems of the Jahorine Mts.]. *Godišnjak Biološkog Instituta Univerziteta u Sarajevu* **30**: 5–19 (in Bosnian).

Dobat K. 1975: Die Höhlenfauna der Schwäbischen Alb mit Einschluß des Dinkelberges, des Schwarzwaldes und des Wutachgebietes. *Jahreshefte der Gesellschaft für Naturkunde in Württemberg* **130**: 260–381.

Dobat K. 1978: Die Höhlenfauna der Fränkischen Alb. *Berichte der Naturwissenschaftlichen Gesellschaft Bayreuth* **16**: 11–132.

Dumitrescu M. & Orghidan T. 1969: Nouvelles données obtenues dans l'étude de la faune Lithoclasicole. *Lucrarile si Institutul Speologie* "*E. Racovitza*" **8**: 55–71.

Dunger W. 1958: Über die Zersetzung der Laubstreu durch die Boden-Makrofauna im Auenwald. *Zoologische Jahrbücher*, *Abteilung für Systematik*, *Ökologie und Geographie der Tiere* **86**: 129–180.

Dunger W. 1966: Myriopoden-Beobachtungen in der Oberlausitz. *Abhandlungen und Berichte des Naturkundemuseums Görlitz* **41**: 39–44.

Dunger W. 1967: Studien an der Myriopodenfauna von Sachsen. Pp.: 105–113. In: Tesař Z. (ed): *II. Entomologisches Symposium über die Probleme der faunistischen und entomogeographischen Erforschung der Tschechoslowakei und Mitteleuropas*]. Opava: Slezské Museum v Opavě, 385 pp.

Dunger W. 1968: Die Entwicklung der Bodenfauna auf rekultivierten Kippen und Halden des Braunkohlentagebaues. Ein Beitrag zur pedobiologischen Standortsdiagnose. *Abhandlungen und Berichte des Naturkundemuseums Görlitz* **43**(2): 1–256.

Edwards C. A. T. 1958: The ecology of Symphyla. Part I. Populations. *Entomologia Experimentalis et Applicata* **1**: 308–319.

Edwards C. A. T. 1959a: Keys to the genera of Symphyla. *Journal of the Linnean Society of London, Zoology* **44**: 164–169.

Edwards C. A. T. 1959b: A revision of the British Symphyla. *Proceedings of the Zoological Society of London* **132**: 403–439.

Edwards C. A. T. 1959c: The ecology of Symphyla. II Seasonal soil migration. *Entomologia Experimentalis et Applicata* **2**: 257–267.
Edwards C. A. T. 1961: The ecology of Symphyla. III Factors controlling soil distributions. *Entomologia Experimentalis et Applicata* **4**: 239–256.
Edwards J. L., Lane M. A. & Nielsen E. S. 2000: Interoperability of biodiversity databases: biodiversity information on every desktop. *Science* **289**: 2312–2314.
Ellingsen E. 1905: Myriopoden der Umgebung von Marburg (Hessen), gesammelt von Herrn Embr. Strand. *Zoologischer Anzeiger* **29**: 201–203.
Eichler W. 1952: *Die Tierwelt der Gewächshäuser*. Leipzig: Akademische Verlagsanstalt Geest & Portig KG, 93 pp.
Evans W. 1907: The Myriapods (Centipedes and Millipedes) of the Forth Area; Part 2. *Proceedings of the Royal Physical Society of Edinburgh* **17**: 109–120.
Foddai D., Minelli A., Scheller U. & Zapparoli M. 1995: Chilopoda, Diplopoda, Pauropoda, Symphyla. In: Minelli A., Ruffo S. & La Posta S. (eds): *Checklist delle Specie della Fauna Italiana 32*. Bologna: Calderini, 35 pp.
Franciscolo M. 1955: Fauna cavernicola del Savonese. *Annali del Museo Civico di Storia Naturale Giacomo Doria* **67**: 1–223.
Franz H., Gunhold P. & Pschorn-Walcher H. 1959: Die Kleintiergemeinschaften der Auwaldböden der Umgebung von Linz und benachbarter Flussgebiete. *Naturkundliches Jahrbuch der Stadt Linz* **1959**: 7–64.
Friedel H. 1928: Ökologische und physiologische Untersuchungen an Scutigerella immaculata (Newp.). *Zeitschrift für Morphologie und Ökologie der Tiere* **10**: 738–797.
Gisin H. 1947: Pauropodes de la Suisse. *Mitteilungen der Schweizerischen Entomologischen Gesellschaft* **20**: 597–604.
Gisin H. 1949: Symphyles de la Suisse. *Archives des Sciences et Compte Rendu des Séances de la Société* **2**: 182–186.
Gisin H. 1951: Sur les espèces européennes de Scutigerella (Myriapodes Symphyles). *Vie et Milieu* **2**: 459–460.
Griepenburg W. 1939: Die Tierwelt der beiden Hüllöcher im Sauerland. *Mitteilungen über Höhlen- und Karstforschung* **1939**: 72–79.
Griepenburg W. 1941: Die Tierwelt der Bilsteinhöhlen bei Warstein in Westfalen. *Zeitschrift für Karst- und Höhlenkunde* **1941**: 190–196.
Guttmann R. 1979: *Untersuchungen zur Entwicklung der Bodenfauna rekultivierter Schutthalden eines Stahlwerkes*. Unpublished PhD Thesis. Braunschweig: Technische Universität Carolo-Wilhelmina zu Braunschweig, 140 pp.
Haase E. 1884: [no title]. *Zeitschrift für Entomologie*, *Breslau*, *Neue Folge* **9**: 28–29.
Haase E. 1885: Schlesiens Symphylen und Pauropoden. *Zeitschrift für Entomologie*, *Breslau*, *Neue Folge* **10**: 1–16.
Hansen H. J. 1902: On the genera and species of Pauropoda. *Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjöbenhavn* **53**: 323–424.
Hågvar S. 1997: Protura, Pauropoda and Symphyla in Norwegian coniferous forest soil: abundance and vertical distribution. *Pedobiologia* **41**: 56–61.
Hansen H. J. 1903: The genera and species of the order Symphyla. *Quarterly Journal of Microscopical Science* **47**(1): 1–101.
Hasenhütl K. 1984: Neue Zwergtausendfüßer aus der Steiermark und angrenzenden Gebieten (Myriapoda, Pauropoda). *Mitteilungen des Naturwissenschaftlichen Vereins für Steiermark* **114**: 272–301.
Hasenhütl K. 1985: Die Eurypuropodidenfauna der Steiermark und angrenzender Gebiete in zoogeographischer Sicht (Myriapoda, Pauropoda). *Mitteilungen des Naturwissenschaftlichen Vereins für Steiermark* **115**: 105–114.
Hasenhütl K. 1986: Systematik der Eurypauropodinae (Tracheata, Dignata, Pauropoda). *Verhandlungen des Naturwissenschaftlichen Vereins in Hamburg* **28**: 129–194.
Hasenhütl K. 1987: Neue Zwergtausendfüßer aus Kärnten (Myriapoda, Pauropoda). *Carinthia II*, *Sonderheft* **45**: 17–75.
Hass H. J. 1958: Zweiter Fund einer Pauropodenart in Hamburg. *Entomologische Mitteilungen des Zoologischen Museums Hamburg* **15**: 444.
Haupt J. 1969: Zur Feinstruktur der Maxillarnephridien von Scutigerella immaculata Newport (Symphyla, Myriapoda). *Zeitschrift für Zellforschung und Mikroskopische Anatomie* **101**: 401–407.
Haupt J. 1971: Beitrag zur Kenntnis der Sinnesorgane von Symphylen (Myriapoda) II. Feinstruktur des Tömösväry'schen Organs von *Scutigerella immaculata* Newport. *Zeitschrift für Zellforschung und Mikroskopische Anatomie* **122**: 172–189.
Haupt J. 1973: Die Ultrastruktur des Pseudoculus von Allopauropus (Pauropoda) und die Homologie der Schläfenorgane. *Zeitschrift für Morphologie der Tiere* **76**: 173–191.
Haupt J. 1976: Die segmentalen Kopfdrüsen von Scutigerella (Symphyla, Myriapoda). *Zoologische Beiträge*, *Neue Folge* **22**: 19–37.
Haupt J. 1977: Untersuchung zur Verbreitung und Phänologie von Scutigerella causeyae (Symphyla), Allopauropus vulgaris (Pauropoda) und Eosentomon transitorium (Protura) im Berliner Naturschutzgebiet Langes Luch. *Sitzungsberichte der Gesellschaft Naturforschender Freunde in Berlin*, *Neue Folge* **17**: 28–38.

Herbke G. 1962: Untersuchungen über das Vorkommen von Tausendfüßlern in landwirtschaftlich genutzten Böden des Dauerdüngungsversuches auf Dikopshof. *Monographien zur Angewandten Entomologie* **16**: 13–43.
Hirschenberger A. 1953: Contribution à la faune des Symphyles de Corse. *Bulletin du Muséum National d'Histoire Naturelle* **25**: 90–94.
Hüther W. 1959: Zur Ernährung der Pauropoden. *Naturwissenschaften* **46**(19): 563–564.
Hüther W. 1971: Zwei interessante Pauropoden aus dem Oberrheingebiet. *Mitteilungen der Pollichia*, *Reihe III* **18**: 170–177.
Hüther W. 1974: Zur Bionomie mitteleuropäischer Pauropoden. *Symposia of the Zoological Society of London* **32**: 411–421.
Hüther W. 1975: Ein neuer Decapauropus aus der Pfalz. *Revue d'Ecologie et de Biologie du Sol* **12**: 487–491.
Hüther W. 1982: Symphylen und Pauropoden des Bausenbergs. *Decheniana Beihefte* **27**: 56–75.
Hüther W. & Kinkler H. 2013: Zwei wenig bekannte Gruppen der Tausendfüßer, "Wenigfüßer" und "Zwergfüßer" des Naturschutzgebiets Gronenborner Teiche in Leverkusen (Myriapoda: Pauropoda, Symphyla). *Decheniana* **166**: 51–54.
Juberthie-Jupeau L. 1957: Etude de la collection des Symphyles du Museum d'Amsterdam. *Entomologische Berichten* **17**: 27–30.
Juberthie-Jupeau L. 1961: Biospeleologica LXXX. Faune cavernicole et endogée de l'île de Minorque. Mission H. Coiffait et P. Strinati (1958). 6. Symphyles de Minorque. *Archives de Zoologie Expérimentale et Générale* **99**: 273–276.
Juberthie-Jupeau L. 1963: Scutigerella remyi n. sp., Symphyle nouveau récolté en Basse-Autriche. *Bulletin du Museum National d'Histoire Naturelle* **35**: 172–175.
Juberthie-Jupeau L. & Tabacaru I. 1968: Symphyles de Roumanie. *Bulletin du Muséum National d'Histoire Naturelle*, *2e série* **40**: 500–517.
Jueg U. 2009: Klasse: Myriapoda (Tausendfüßer). Pp.: 265–266. In: Jueg U. (ed.): *Flora und Fauna im Landschaftsschutzgebiet* "*Schlosspark Ludwigslust*". *Mitteilungen der Naturforschenden Gesellschaft West-Mecklenburg Sonderheft* **1**: 1–326.
Kováč L., Elhottová D., Mock A., Nováková A., Krištůfek V., Chroňáková A., Lukešová A., Mulec J., Košel V., Papáč V., Ľuptáčik P., Uhrin M., Višňovská Z., Hudec I., Gaál Ľ. & Bella P. 2014: *The Cave Biota of Slovakia*. Banská Bystrica: State Nature Conservancy of the Slovak Republic, 192 pp.
Krauß J., Spelda J. & Funke W. 1998: 5.2 Mesofauna des Bodens. Pp.: 241–248. In: Fischer A. (eds): *Die Entwicklung von Wald-Biozönosen nach Sturmwurf. Umweltforschung in Baden-Württemberg*. Landsberg: Ecomed Verlagsgesellschaft, 427 pp.
Latzel R. 1884: *Die Myriopoden der Österreichisch-ungarischen Monarchie*. *Zweite Hälfte*: *Die Symphylen*, *Pauropoden und Diplopoden*. Wien: Alfred Hölder, 414 pp.
Latzel R. 1895: Die Myriopoden aus der Umgebung Hamburgs. *Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten*, *Beiheft* **12**: 99–109.
Lehmitz R., Russell D., Hohberg K., Christian A. & Xylander W. E. R. 2012: Active dispersal of oribatid mites into young soils. *Applied Soil Ecology* **55**: 10–19.
Leinaas H. P. 1974: Symphyla and pauropoda from two coniferous forests in south Norway. *Norsk Entomologisk Tidskrift* **21**: 161–166.
Lengersdorf F. 1961: Die lebende Tierwelt der westfälischen Höhlen. *Jahreshefte für Karst- und Höhlenkunde* **2**: 193–226.
Loksa I. 1966: *Die bodenzönologischen Verhältnisse der Flaumeichen-Buschwälder Südost-Mitteleuropas. Monografie der Flaumeichen-Buschwälder II*. Budapest: Verlag der Ungarischen Akademie der Wissenschaften, 437 pp.
Marcuzzi G. 1956: Fauna delle Dolomiti. *Memorie Classe die Scienza Mathematche e Naturali* **31**: 1–595.
Michelbacher A. E. 1942: A synopsis of the genus Scutigerella (Symphyla, Scutigerellidae). *Annals of the Entomological Society of America* **35**(3): 267–288.
Michelbacher A. E. 1949: The ecology of Symphyla. *Pan-Pacific Entomologist* **25**: 1–11.
Mühlmann H. 1942: Die rezente Metazoenfauna der Harzer Höhlen und Bergwerke. Myriapoda. *Zoogeographica* **4**: 220–222.
Pax F. 1936: Die Reyersdorfer Tropfsteinhöhle und ihre Tierbevölkerung. *Mitteilungen über Höhlen- und Karstforschung* **3**: 97–122.
Plachter H. & Plachter J. 1988: Ökologische Studien zur terrestrischen Höhlenfauna Süddeutschlands. *Zoologica* **47**(139): 1–67.
Postner M. 1951a: Biologisch-ökologische Untersuchungen an Hummeln und ihren Nestern. *Veröffentlichungen aus dem Museum für Natur-*, *Völker- und Handelskunde in Bremen* **2**: 45–86.
Postner M. 1951b: *Biologisch-ökologische Untersuchungen an Hummeln und deren Nestern und biologische Beobachtungen an Hummelmilben*. Unpubl. PhD Thesis. Erlangen: Friedrich-Alexander-Universität Erlangen-Nürnberg, 106 pp.
Rafalski J. 1977: Materialy do fauny Pauropoda Polski, I. Rodzaj Brachypauropus Latzel, 1884. *Annales Zoologici* **33**(19): 435–444.

Remy P. 1935: Diagnoses de Pauropodes nouveaux. *Vogesia* **1**(2): 6–8.
Remy P. 1936a: Beitrag zur Fauna der Myriapoden Deutschlands, mit Beschreibung neuer Arten. *Zoologischer Anzeiger* **116**: 310–320.
Remy P. 1936b: Pauropodes de France et des Balkans, avec descriptions d'espèces nouvelles. *Archives de Zoologie Expérimentale et Générale* **78**: 13–31.
Remy P. 1938: Pauropodes de France, d'Allemagne et des Balkans, avec description de quatre formes nouvelles. *Bulletin de la Société d'Histoire Naturelle de la Moselle* **35**: 153–178.
Remy P. 1939: Etudes Biospéologiques XVIII (1). Roumanie. 6. Contribution à la faune endogée du Bihor et des Carpathes méridionales: Pauropoda récoltés par R. Leruth. *Bulletin du Musee Royal d'Histoire Naturelle de Belgique* **15**(67): 1–43.
Remy P. 1941: Contribution à la faune des Myriapodes de France. *Bulletin de la Société Zoologique de France* **66**: 351–373.
Remy P. 1943: Stations européennes de symphyles, avec description d'une espèce nouvelle. *Archives de Zoologie Expérimentale et Générale*, *Notes et Revue* **13**(3): 1–21.
Remy P. 1946: Additions à la faune française des myriapodes. *Archives de Zoologie Expérimentale et Générale* **85**: 19–25.
Remy P. 1960: Pauropodes d'Italie. *Bulletin de la Societe Entomologique de France* **65**: 294–300.
Remy P. 1961a: Biospeologica LXXX. Faune cavernicole et endogée de l'île de Minorque. Mission H. Coiffait et P. Strinati. Pauropodes et Palpigrades. *Archives de Zoologie Expérimentale et Générale* **99**: 267–272.
Remy P. 1961b: Stations de Symphyles et de Pauropodes; description d'une espèce nouvelle d'Allopauropus. *Bulletin de l'Académie Lorraine des Sciences* **1**: 81–99.
Remy P. 1961c: Sur la microfaune du sol de Grande-Bretagne. I. Pauropodes. *Annals and Magazine of Natural History, Series* 13 **4**(39): 149–153.
Remy P. 1962: Synopsis des Pauropodes d'Autriche. Additions á cette faune. *Bulletin de la Société Lorraine* **2**: 42–51.
Remy P. & Balland A. 1958: Pauropodes de France méridionale. *Revue Francaise d'Entomologie* **24**: 396–409.
Remy P. & Hoffmann J. 1959: Faune des Myriapodes du Grand-Duché de Luxembourg. *Archives Institut Gran-Duchal Luxembourg Section des Sciences Naturelles, Physiques et Mathematiques, Nouvelle Série* **25**: 199–236.
Remy P. & Husson R. 1938: Les pauropodes des galeries de mines et des cavernes naturelles. Pp.: 1–19 In: Société de Sciences de Nancy (eds): *Comptes Rendus du Premier Congrès Lorrain des Sociétés Savantes de l'est de la France. Nancy 6-8 Juin 1938. Tome 3.* Nancy: Société de Sciences de Nancy, 267 pp.
Rochaix B. 1955: Symphyles des Dolomites. *Atti dell'Istituto Veneto di Scienze*, *Lettere ed Arti* **63**: 11–18.
Rusek J. 2001a: Pauropoda of the Czech and Slovak Republics. *Myriapodologica Czecho-Slovaca* **1**: 5–7.
Rusek J. 2001b: Symphyla of the Czech and Slovak Republics. *Myriapodologica Czecho-Slovaca* **1**: 9–10.
Salt G., Hollick F. S. J., Raw F. & Brian M.V. 1948: The arthropod population of pasture soil. *Journal of Animal Ecology* **17**: 139–150.
Sawa R. 1930: A preliminary survey of the arthropodan fauna of the University of Komaba. *Journal of the College of Agriculture*, *Imperial University of Tokyo* **10**: 329–345.
Scheller U. 1952: A new species of the order Symphyla from South Sweden. *Kungliga Fysiografiska Sällskapets i Lund förhandlingar* **22**(12): 1–7.
Scheller U. 1954: Symphyla and Pauropoda from Denmark. *Entomologiske Meddelelser* **27**(1): 1–18.
Scheller U. 1960: En för Sverige ny skadegörare i växthus, *Scutigerella immaculata* Newp. part. Michelb. (Symphyla). *Växtskydds-notiser* **24**(3): 38–41.
Scheller U. 1961: Cave Symphyla from Switzerland. *Revue Suisse de Zoologie* **68**(35): 419–424.
Scheller U. 1962: Some Symphyla and Pauropoda from South-Western Germany. *Mitteilungen des Badischen Landesvereins für Naturkunde und Naturschutz*, *Freiburg i. Br.*, *Neue Folge* **8**: 261–265.
Scheller U. 1968: New Records of Symphyla from Central and Southern Europe. *Berichte des Naturwissenschaftlich-medizinischen Vereins in Innsbruck* **56**: 125–141.
Scheller U. 1973: Pauropoda and Symphyla from the Pyrenees. *Revue d'Ecologie et de Biologie du Sol* **10**: 131–149.
Scheller U. 1974a: The Pauropoda and Symphyla of the Geneva Museum I. A synopsis of the genus Gravieripus (Myriapoda, Pauropoda, Eurypauropodidae). *Revue Suisse de Zoologie* **81**: 613–631.
Scheller U. 1974b: Pauropoda from arable soil in Great Britain. *Symposia of the Zoological Society of London* **32**: 405–410.
Scheller U. 1976: The Pauropoda and Symphyla of the Geneva Museum II. A review of the Swiss Pauropoda (Myriapoda). *Revue Suisse de Zoologie* **83**: 3–37.
Scheller U. 1977a: The Pauropoda and Symphyla of the Geneva Museum IV. A basic list of the Pauropoda of Greece (Myriapoda). *Revue Suisse de Zoologie* **84**: 361–408.
Scheller U. 1977b: The Pauropoda and Symphyla of the Geneva Museum III. On the identification of immature stages in Gravieripus cordatus Scheller (Myriapoda, Pauropoda, Eurypauropodidae). *Revue Suisse de Zoologie* **84**: 221–228.

Scheller U. 1978: The Pauropoda and Symphyla of the Geneva Museum V. A review of the Swiss Scolopendrellidae (Myriapoda, Symphyla). *Revue Suisse de Zoologie* **85**: 247–263.
Scheller U. 1982: Pauropoda from southern Finland. *Memoranda Societatis pro Fauna et Flora Fennica* **58**(1): 27–31.
Scheller U. 1990: A list of British Pauropoda with description of a new species of Eurypauropodidae (Myriapoda). *Journal of Natural History* **24**: 1179–1195.
Scheller U. 2002: A new species of Hanseniella Bagnall (Myriapoda, Symphyla) found in a hothouse. *Mitteilungen aus dem Museum für Naturkunde in Berlin*, *Zoologische Reihe* **78**: 269–273.
Scheller U. 2008: A reclassification of the Pauropoda (Myriapoda). *International Journal of Myriapodology* **1**: 1–38.
Schmid G. 1966: Die übrige "niedere" Tierwelt des Spitzbergs. Pp.: 998–1027. In: Landesstelle für Naturschutz und Landschaftspflege Baden-Württemberg (eds): *Der Spitzberg bei Tübingen*. Ludwigsburg: Natur und Landschaftsschutzgebiete Baden-Württembergs, 1141 pp.
Schubart O. 1938: Ein für Deutschland neuer Diplopode aus westdeutschen Höhlen. *Mitteilungen über Höhlen- und Karstforschung* **1938**: 133–137.
Schubart O. 1964: Diplopoda, Symphyla, Pauropoda, Chilopoda. Ergänzung – Oberklasse Progonéata / Oberklasse Opisthogoneata. In: Brohmer P., Ehrmann, P. & Ulmer G. (eds): *Die Tierwelt Mitteleuropas*. *II. Band, Lief. 3. Ergänzung*. Leipzig: Quelle & Meyer, 55 pp.
Schuster R. 1960: Allgemeine faunistische Nachrichten aus Steiermark (VII). Arthropoda. *Mitteilungen des Naturwissenschaftlichen Vereins für Steiermark* **90**: 5–7.
Schuster R. 1978: Faunistische Nachrichten aus der Steiermark (XXIII/4). Zur Verbreitung der Tausendfüßer-Familie Eurypauropidae (Myriapoda, Pauropoda). *Mitteilungen des Naturwissenschaftlichen Vereins für Steiermark* **108**: 289–292.
Seifert G. 1953: *Beiträge zur Kenntnis der Myriapodenfauna des Mittleren Saaletals*. Unpublished Diploma Thesis. Jena: Friedrich-Schiller-Universität Jena, 52 pp.
Spelda J. 2005: Improvements in the knowledge of the myriapod fauna of southern Germany between 1988 and 2005 (Myriapoda: Chilopoda, Diplopoda, Pauropoda, Symphyla). *Peckiana* **4**: 101–129.
Starling J. H. 1944: Ecological studies of the Pauropoda of the Duke Forest. *Ecological Monographs* **14**: 291–310.
Strinati P. 1969: Faune cavernicole de la Haute-Savoie (France). IV. *Actes du IVe Congres International de Speleologie en Yougoslavie* **4-5**: 231–239.
Uhlmann E. 1940: Die Tierwelt Jenas. Pp.: 61–102. In: Lehmann W. (ed.): *Jena. Thüringens Universitätsstadt in Vergangenheit und Gegenwart. Band 1: Natürliche Grundlagen der Stadt Jena*. Jena: Verlag Gustav Fischer, 102 pp.
Verhoeff K. W. 1901: Beiträge zur Kenntniss paläarktischer Myriopoden. XIX. Aufsatz: Diplopoden aus Herzegowina, Ungarn und Baiern. *Archiv für Naturgeschichte* **67**: 221–240.
Verhoeff K. W. 1934: Gliederfüßler: Arthropoda, II. Abteilung: Myriapoda. 3. Buch: Symphyla und Pauropoda. In: Bronn H. G (ed.): *Klassen und Ordnungen des Tierreichs* **5**(2): 1–200.
Weber D. 1991: Die Evertebratenfauna der Höhlen und künstlichen Hohlräume des Katastergebietes Westfalen einschließlich der Quellen- und Grundwasserfauna. *Abhandlungen zur Karst- und Höhlenkunde* **25**: 1–701.
Weber D. 1995: Die Höhlenfauna und -flora des Höhlenkatastergebietes Rheinland-Pfalz/Saarland 3. Teil. *Abhandlungen zur Karst- und Höhlenkunde* **29**: 1–322.
Weber D. 2001: Die Höhlenfauna und –flora des Höhlenkatastergebietes Rheinland-Pfalz/Saarland 4. Teil. *Abhandlungen zur Karst- und Höhlenkunde* **33**: 1–1088.
Weber D. 2012: Die Höhlenfauna und -flora des Höhlenkatastergebietes Rheinland-Pfalz/Saarland, 5. Teil. *Abhandlungen zur Karst- und Höhlenkunde* **36**: 1–2367.
Würmli M. 1972: Catalogus Faunae Austriae, XIa: Klasse: Myriapoda. U.-Klasse: Symphyla. *Catalogus Faunae Austriae* **11a**: 17–19.
Zaenker S. 2008: Das Biospeläologische Kataster von Hessen – Die Fauna der Höhlen, künstlichen Hohlräume und Quellen. *Abhandlungen zur Karst- und Höhlenkunde* **32**: CD-ROM 12. April 2008 version.
Zerm M. 1996: *Myriapode Antennata und terristische Isopoda (Diplopoda, Chilopoda, Symphyla; Oniscidea) im Nationalpark Unteres Odertal, unter besonderer Berücksichtigung des Standortfaktors Überschwemmung*. Unpubl. Thesis. Berlin: Freie Universität Berlin, 210 pp.
Zerm M. 1997: Die Fauna der Tausend-, Hundert- und Zwergfüßer (Myriapoda: Diplopoda, Chilopoda, Symphyla) sowie der Landasseln (Isopoda: Oniscidea) im Unteren Odertal, unter besonderer Berücksichtigung des Standortfaktors Überschwemmung. *Zoologische Beiträge*, *Neue Folge* **38**: 97–134.
Zerm M. 1999: Vorkommen und Verteilung von Tausendfüßern, Hundertfüßern, Zwergfüßern (Myriapoda: Diplopoda, Chilopoda, Symphyla) und Landasseln (Isopoda: Oniscidea) in den Auen des Unteren Odertals. *Limnologie Aktuell* **9**: 197–210.
Živadinović J., Cvijović M. & Dizdarević M. 1967: Successions of animal populations in the soil on the Serpentine Rocks. *Godišnjak Biološkog Instituta Univerziteta u Sarajevu* **20**: 67–83.

Acta Soc. Zool. Bohem. **80**: 87–99, 2016
ISSN 1211-376X

Myriapods (Myriapoda) occurring on plains and in mountain ecosystems on the Kola Peninsula (Russia)

Irina V. Zenkova

Institute of the Industrial Ecology Problems of the North, Kola Science Centre, Russian Academy of Sciences, Akademgorodok 14a, Apatity, Murmansk region, 184209, Russia; e-mail: zenkova@inep.ksc.ru

Received 18 June 2015; *accepted 18 November 2015*
Published 12 April 2016

Abstract. Based on the literature there are five species of myriapod, four species of centipede (Chilopoda) and one symphylan (Symphyla) recorded on the Kola Peninsula. During research in different biogeographical subzones on the Kola Peninsula, only three species of centipede were found: *Lithobius curtipes* C. L. Koch, 1847, *Lithobius forficatus* (Linnaeus, 1758), and *Geophilus proximus* Koch, 1847. The polyzonal eurytopic species *L. curtipes* occurred widespread along a latitudinal gradient from the White Sea Islands to the tundra ecosystems on the coast of the Barents Sea and in all mountain belts on the Hibiny Mountain Massive up to the high-altitude rocky desert. *G. proximus* is rare on the Kola Peninsula and it is probable that the limit of its distribution coincides with the timberline on both the plains and in mountain habitats. *L. forficatus* was found only once in northern taiga forest in the continental part of the region. Millipedes (Diplopoda) were not recorded, although they occur in the neighbouring Republic of Karelia (Russia) and in northern areas of Scandinavian countries. The poverty of the myriapod fauna is due to the geographic position of this region inside the Arctic Circle, a cool, humid climate and acid podzol soils with low content of calcium. A map of the distribution of myriapod species on the Kola Peninsula is presented and the results of a six-year study of the altitudinal distribution of centipedes on the Hibiny Mountain Massive are summarized.

Key words. Distribution, density, latitudinal gradient, high-altitude gradient, soil parameters, Myriapoda, Russia, Kola Peninsula.

INTRODUCTION

Myriapod fauna of the Russian Federation includes at least 264 species in four classes: 180 millipedes (Diplopoda), 80 centipedes (Chilopoda), two pauropods (Pauropoda) and two symphylans (Symphyla) (Skarlato et al. 1994, Golovach 1995, Shileyko 1995). Five species are known from the Kola Peninsula. Four centipede species were noted at the beginning of the 20th century: two lithobiomorph species – *Lithobius* (*Monotarsobius*) *curtipes* Koch, 1847, and *Lithobius forficatus* (Linnaeus, 1758), and two geophilomorph species – *Geophilus proximus* Koch, 1847, and *Pachymerium ferrugineum* (Koch, 1835) (Palmen 1948). The occurrence of these species was confirmed during a ten-year study of the soil fauna on the White Sea Islands in the Kandalakša Nature Reserve in the southern part of the Kola Peninsula (Byzova et al. 1986, Tchesunov et al. 2008, Koryakin et al. 2009). In addition, one species belonging to the genus *Symphylella* (Symphyla) was found on these Islands (Byzova et al. 1986). Currently information about the distribution of species on the Kola Peninsula is fragmented, including the data on the ecology of *L. curtipes*. This species is known to occur in the tundra zone on the coast of the Barents Sea (69° N, 36° E; Striganova 1973, Evdokimova et al. 2006), in the Pasvik Nature Reserve on the border of northern taiga/forest-tundra (69° N, 29° E; Zenkova 2012) and in natural and industrially polluted forest soils in the central part of the region (Zenkova 1999, 2000, Evdokimova et al. 2002, 2005, Zenkova & Petrashova

2003, 2008a, b, Petrashova 2009, 2010). There is no information on the diversity and altitudinal distribution of myriapods in mountain ecosystems on the Kola Peninsula.

In the period 1996–2014 we studied the soil fauna in a wide range of natural and anthropogenic ecosystems from the northern taiga subzone on the Kola Peninsula to forest-tundra and tundra province on the coast of the Barents Sea, including mountain ecosystems on the alkaline Hibiny Mountain Massive and in the protected Pasvik Nature Reserve. The latitudinal distribution of myriapod species on the Kola Peninsula and an analysis of six-year research on the altitudinal distribution of centipedes in the mountains in this polar region are summarised in this article.

MATERIALS AND METHODS

Fifty-seven sites in northern taiga, forest-tundra and tundra subzones on the Kola Peninsula were investigated (Figs. 1, 2). Within the forest-tundra and tundra (68° 10' – 69° 19' N, 29° 36' – 34° 17' E), four sites along the Barents Sea coast were investigated: a plot of birch forest-tundra (T1), typical plain tundra (T2) and the littoral zone on the seashore (T3) in 2006, and several plots along low-level upland at Dal'nie Zelency (T4) in 2009. On the border between forest-tundra/northern-taiga a plain secondary birch forest (PRB) and nine mountain sites (PRM), including three rare pine forests, three birch tortuous forests and three mountain tundra sites were studied in the protected Russian area in the cross-border Pasvik Nature Reserve (69° 08–18' N, 29° 14–27' E) in 2010–2013. Within the northern taiga (66° 56' – 67° 35' N, 29° 36' – 34° 17' E), ten native forest sites were studied from 1996 to 2007, which included five spruce forests (S1–S5) and five

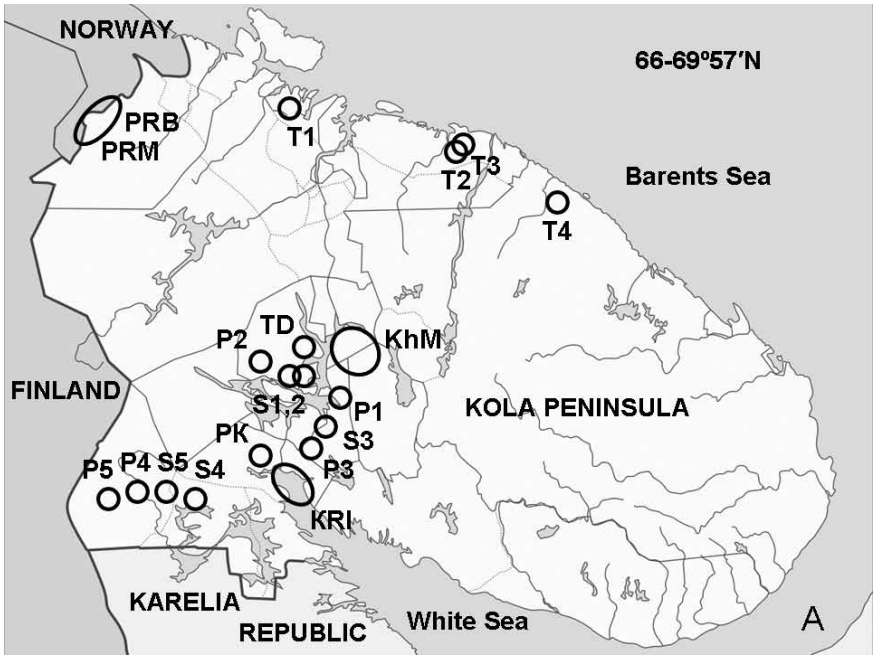


Fig. 1. Sites studied on the Kola Peninsula. Tundra and forest-tundra floristic province. T1 – Vidâevo, T2 – Teriberka, T3 – Barents Sea littoral zone, T4 – Dal'nie Zelency. Boundary between forest-tundra/northern taiga: PRB – Pasvik Nature Reserve plain birch, PRM – Pasvik Nature Reserve Mountains. Northern-taiga: P1–P5 – pine forests, S1–S5 – spruce forests, TD – technogenic desert resulting from industrial fall-out 5 km from the "Severonikel" plant, PK – damaged pine forest in the fall-out zone 2 km from the Kandalakša aluminium plant, KRI – White Sea Islands in the Kandalakša Nature Reserve, KhM – Hibiny Mountain Massive.

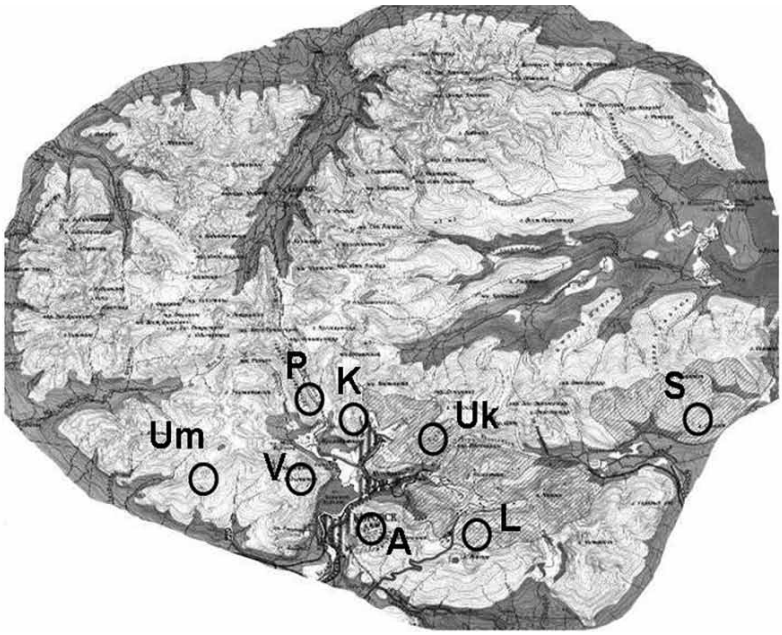


Fig. 2. Sites studied on the Hibiny Mountain Massive. L – Lovčorr Mt, Uk – Uksporr Mt, K – Kukisvumčorr Mt, Um – Umečorr Mt, A – Ajkâjvenčorr Mt, V – Vudjâvrčorr Mt, P – Poačvumčorr Mt, S – Suolaiv Mt.

pine forests (P1–P5). All coniferous forests were approximately 100-150 years old with a well-developed vegetative cover, including shrubs, grasses, mosses and lichens in different proportions. Several disturbed sites were investigated along two gradients of soil pollution: (1) – at distances of 5, 15 and 30 km from the Severonikel copper-nickel plant in 1996–2000, and (2) – at distances of 2, 5, 10 and 20 km from the Kandalakša aluminium plant in 2000–2005. On the Hibiny Mountain Massive (KhM; 67° 35–49' N, 33° 14' – 34° 11' E) 26 sites, including rare spruce, pine and birch tortuous forests, high--mountain tundra and rocky desert were studied on the slopes of eight different mountains (Fig. 2). In addition, literature data of a ten-year soil zoological research on 21 White Sea Islands in the Kandalakša Nature Reserve (KRI) in the south of the Kola Peninsula were taken into consideration (Byzova et al. 1986).

Hydromorphic peat soils and semi-hydromorphic peat podzol soils are typical for lowland and mountain tundra on the Kola Peninsula (Pereverzev 2004, 2010, 2013). Shallow iron-illuvial podzols on a sandy moraine prevail in coniferous forests in the Pasvik Nature Reserve. Al-Fe-humus podzol (or humus-illuvial podzol) on sandy moraine deposits is a predominant soil type in the northern taiga, except on the Hibiny Mountain Massive. Dark humus-illuvial podzols (or high-humus podzols) developed on alkaline nepheline syenite rocks rich in minerals under mountain forests and podbur soils with a large amount of organic material under mountain tundra.

Two methods were used to study of invertebrates on the sites: litter sampling and 500 ml Barber traps containing 4% formaldehyde (Barber 1931, Ghilarov 1975). The litter samples, each 25×25 and up to 7(9) cm deep, were collected monthly after the snow melted, beginning in May or June and continuing to September. At each site not less than 5 litter samples and 20–40 traps were used, depending on the heterogeneity of the vegetation cover. The period of the traps set was 2–3 months during the growing season from May–June to August–September. Hand sorting was used to find animals in the litter samples and trap catches, following the electric heating of the litter in the laboratory. All groups of invertebrates were counted in soil samples and trap catches, including myriapods. Centipedes were identified using the keys by Zalesskaja (1978) and Andersson et al. (2005).

The coordinates of the sites, the exposure of the slopes and altitude above sea level were measured using a satellite navigator Garmin eTrex-30. Humidity, acidity (pH H_2O), the ratio of the concentration of humic acids and fulvic acids (Ha/Fa), ash and organic matter content (loss after the burning, %) were determined for litter, using the methods of Arinushkina (1970). Descriptive statistics of the data were calculated using Statistica 6.0 software.

RESULTS

Latitudinal gradient in plain ecosystems

Only three species of centipedes were found in northern taiga forests during this study: *Lithobius curtipes* (several hundred specimens), *Lithobius forficatus* (single specimen), and *Geophilus proximus* (five specimens), but only *L. curtipes* was common in various types of natural and industrially polluted pine and spruce forests growing on a wide range soils (Table 1). In natural ecosystems the highest abundance and biomass of *L. curtipes* were recorded in pine litter (P1) with low acidity and a fulvo-humatic type of soil humus, and the lowest number in water-logged dwarf shrub-green moss spruce forest (S4).

Along the latitudinal gradient only *L. curtipes* occurred up to 69° 19' N in tundra ecosystems on the coast of Barents Sea. In iron-illuvial podzol soils in shrub-grass birch forest in the Pasvik Nature Reserve and in illuvial-humus and peat podzols of typical tundra (sites T1, T2, and T4), the number of *L. curtipes* do not exceed 2–3 ind.m^{-2}. In the sandy littoral zone (T3) it was more numerous and dominated in the littoral fauna of both numbers (18%) and biomass (70%).

In polluted soils in northern taiga subzone *L. curtipes* was less abundant than in natural forest podzols but more abundant than in tundra subzone (Table 1).

In contrast, *L. forficatus* was recorded only once in the continental part *of the region,* in wet blackberry spruce (S1, 67° 35' N, 32° 59' E), on the NE slope of a moraine ridge at an altitude 125 m a. s. l. Several specimens of *G. proximus* were found in different months from the middle of May to the end of September in pine forest automorphic sandy soils in different stages of leaching with the following range of parameters: pH 4.3–4.8, depth 4.5–9.2 cm and soil temperature 5–13 °C. The northernmost record of *G. proximus* was in black crowberry pine at site P2 (67° 34' N).

High-altitude gradient in mountain ecosystems

The species *L. curtipes* and *G. proximus* were both recorded on the Hibiny Mountain Massive in the northern taiga subzone, and only *L. curtipes* was recorded in the mountains in the Pasvik Nature Reserve on the border between northern taiga and forest-tundra. In the Pasvik Nature Reserve *L. curtipes* inhabit the pine forest belt but its density in shallow iron-illuvial podzols did not exceed 2 ind.m^{-2}. In the upper birch forest-tundra belt at an altitude 200–250 m a. s. l. this species occurred only on southern slopes at densities up to 4 ind.m^{-2}, which is similar to the density recorded in plain birch forest at an altitude 45 m a. s. l. Centipedes were not found in hydromorphic podzolic podbur soils in the tundra belt in the mountains at an altitude 270–300 m a. s. l. (Table 2).

In contrast, on the Hibiny Mountain Massive *L. curtipes* occurred in all areas in coniferous spruce and pine forests up to the rocky desert with fragmentary moss and lichen cover on the mountain plateau at an altitude of about 1000 m a. s. l. The density and biomass of *L. curtipes* recorded in open habitats in areas of high mountain tundra and rocky desert were comparable and even exceeded those in northern-taiga coniferous forests on the plain (Tables 1 and 2). *L. curtipes* was most numerous (up to 144 ind.m^{-2}) in intrazonal plant communities on warm and wet S and SE facing slopes. Based on the soil analysis, the layers of debris at these sites were less acidic (pH 5.3–5.6) and contained more organic matter (60–80%). Single individuals of *G. proximus* were recorded at such sites only (Fig. 3).

DISCUSSION

Kola Peninsula is an arctic region interesting from a geographical point of view because of the presence of a high diversity of different zones both in terms of latitude and altitude. Along the latitudinal gradient there is a succession of coniferous northern taiga, birch forest-tundra and typical tundra. At high-altitudes there are gradients in climatic and edaphic factors. As a result,

Table 1. Density and biomass of *Litobius curtipes* in the plain ecosystems studied on the Kola Peninsula

site	coordinates	altitude m a. s. l.	soil type and litter properties	year studied	no. samples	density ind.m^{-2}	biomass mg.m^{-2}
tundra and forest-tundra on the coast of the Barents Sea							
T1 – lichen-shrub, shrub, moss-shrub forest-tundra; Vidâevo settlements (*Betula pubescens*, *Empetrum hermaphroditum*, *Arctous alpina*)	69° 19' N 32° 52' E	60	hydromorphic peat soils, semi-hydromorphicpeat-podzol soils; depth up to 22 cm; ash content 9–15%; pH 4.2	2006	15	1±1* 0–16**	1±1 0–7
T2 – shrub-lichen tundra; Teriberka settlements (*Vaccinium vitis-idaea*, *V. myrtillus, Empetrum hermaphroditum*, *Chamaepericlymenum suecicum*)	68° 10' N 35° 08' E	45	humus-illuvial podzols on sandy moraine; depth up to 7–8 cm; pH 4.3–5.4		15	1±1 0–16	1±1 0–19
T3 – littoral zone (*Leymus arenarius*)		≤5	fine-grained sea sand deposits; pH 7.2		5	6±3 0–16	29±15 0–50
T4 – shrub, lichen-shrub tundra in a low altitude catena; Dal'nie Zelency settlements	69° 06' N 36° 04' E	55–85	peat podzol soils	2009	40	1±1 0–16	not measured
northern taiga / forest-tundra border (Pasvik Nature Reserve)							
PRB – plain shrub-grass birch forest (*Betula pubescens* f. *subarctica*)	69° 08' N 29° 14' E	45	iron-illuvial podzols on sandy moraine; depth 2–5 cm; pH 5.1–5.6	2011	10	3±2 0–16	5±4 0–46
northern taiga natural forest ecosystems							
spruce forests (*Picea obovata*): S1 – blackberry, S2 – shrub humid, S3 – green moss, S4 – shrub-green moss, S5 – lichen	66° 56' – 67° 35' N 29° 36' – 32° 60' E	125–330	humus-illuvial podzols on sandy moraine; ash content 7–10%; pH 3.7–4.3; humate-fulvatic type of soil humus, Ha/Fa<1.0	2005 –2007	40 on each site	2±1 –13±3 0–80	0.2±0.1 –97±28 0–774
		148–230				4±1 –12±3 0–48	5±4 –50±15 0–215
pine forests (*Pinus sylvestris*): P2 – black crowberry, P3 – shrub, P4, P5 – lichen, P1 – blackberry	67° 34' N 33° 17' E	155	humus-illuvial podzols on lake-glacier sand sediments; ash content 30%; pH 5.5–6.0; fulvo-humatic type of soil humus, Ha/Fa≥1.0	1996 –2007	220	32±3 0–304	120±12 0–845
northern taiga polluted ecosystems							
TD – technogenic desert 5 km from the "Severonikel" copper-nickel plant	67° 34' N 34° 17' E	80	eroded humus-illuvial peat-podzols; concentration mg/kg: Ni 2600, Cu 1280, Co 350, sulphate 400–600; ash content 80–90%; pH 3.5; Ha/Fa 0.9–1.0	1996 –2000	55	7±1	53±20
PK – shrub pine forest (*Empetrum hermaphroditum*); fall-out zone 2 km from Kandalakša aluminium plant	67° 20' N 33° 20' E		humus-illuvial podzols on a moraine consisting of large boulders; fluorine concentration 1200 mg/kg; ash content 60%; pH 4.9–5.7	2000 –2005	110	9±1	30±5

* mean ± standard error recorded at each site; ** spatial variation in density or biomass (variation between soil samples).

there are several types of soil in this region with different thermal and hydrological regimes from automorphic to semi-hydromorphic and hydromorphic (Pereverzev 2004, 2010, 2013). In addition, agriculturally and industrially polluted soils, and technogenic substrates are present with physical and chemical properties that differ from native soils. Despite these factors, there are only five myriapod species recorded in the literature for the Kola Peninsula and only three species of which, *L. curtipes*, *L. forficatus* and *G. proximus*, were repeatedly recorded in this study.

In northern Norway, at the same latitude, the fauna includes not less than eight species of centipedes and seven species of millipedes and along the southern border of Northern Norway, four species of pauropods and three species of symphylans occur (Bergersen et al. 2006). For the whole of Norway, 111 myriapod species are recorded, and for Sweden, approximately 80 species (Table 3). As on the Kola Peninsula, in Northern Norway myriapod diversity decreases northwards from 12 species (seven centipedes and five millipedes) in Nordland (65° N) to 5–6 species in Tromsø and Finnmark (68–70° N), mainly because of the absence there of millipedes. Common in all these counties are species that also are typical for the Kola Peninsula: *L. forficatus* in Nordland, *G. proximus* in Nordland and Tromsø, and *L. curtipes* in Finnmark (Bergersen et al. 2006).

Both *L. forficatus* and *L. curtipes* are widely distributed in Europe and very common in Nordic countries. The holarctic *L. forficatus* is a ubiquitous and synanthropic species. Due to good osmoregulation, it inhabits both xeromorphic and hydromorphic soils (Fairhurst et al. 1978). Obviously, the occurrence and abundance of *L. forficatus* gradually decrease from taiga to forest-tundra

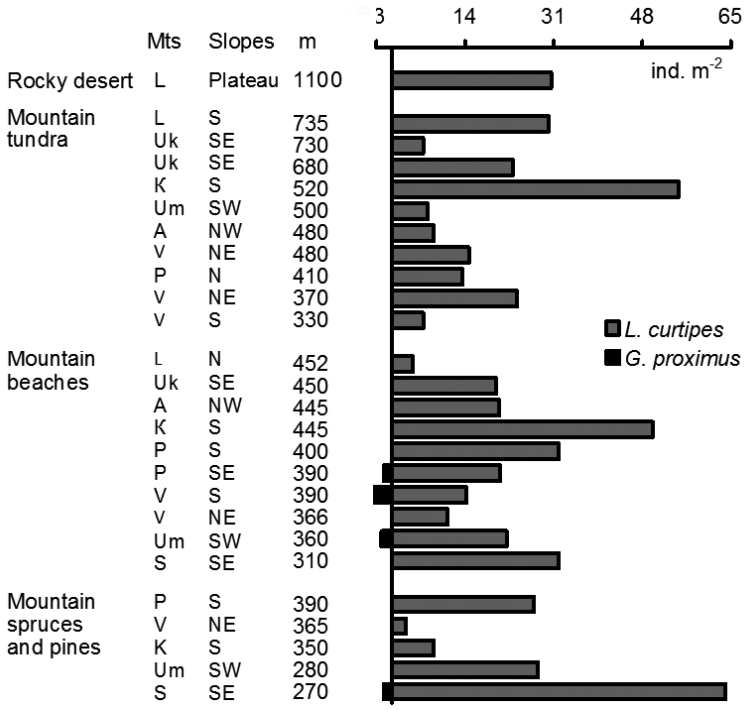


Fig. 3. Numbers of centipedes (ind.m^{-2}) recorded on the Hibiny Mountain Massive. For abbreviation of mountain names see Fig. 2.

Table 2. Density and biomass of *Litobius curtipes* recorded in the mountain ecosystems on the Kola Peninsula. nm = not measured

belts	coordinates	altitude m a. s. l.	soil type	year studied	no. samples	no. ind./m^2	biomass mg/m^2
northern taiga / forest-tundra border, mountains of the Pasvik Nature Reserve (PRM)							
lichen-shrub tundra	69° 14–18' N 29° 22–27' E	273–303	podzolic podburs with cryogenic spots; pH 4.4–5.7	2010–2013	30	0	0
shrub, grass, moss, birch tortuous forests (*Betula pubescens tosrtuoa*)		200–250	hydromorphic and semi-hydromorphic peat-podzols; depth up 10–13 cm; pH 4.5–5.1		30	1±1 0–16	not measured
shrub, lichen-shrub pine sparse forests (*Pinus sylvestris laponica*)		125–155	humus-illuvial and iron-illuvial podzols; depth 1.5–5 cm; pH 4.5–5.1		30	1±1 0–16	not measured
northern taiga, Hibiny Mountain Massive (KhM)							
rocky desert on high-mountain plateau with fragmentary lichen-shrub cover	67° 35–49' N 33° 14' – 34° 11' E	1100	rocky bedrock; ash content 70–90%; pH 5.5–6.0	2008–2013	20	31±7 0–144	125±35 0–680
shrub, lichen-shrub, lichen-shrub-moss tundra		330–735	podzolic podburs; ash content 33–84%; pH 4.4–5.9		105	19±2 0–150	125±30 0–1680
shrub, grass and moss-grass birch (*Betula tortuosa*) forests		310–450	high-humus illuvial podzol soils on alkaline nepheline syenites; ash content 20–86%; pH 4.2–5.9		115	20±3 0–160	60±16 0–730
shrub-grass-moss spruce (*Picea obovata*) and pine (*Pinus sylvestris*) sparse forests		270–390			55	17±3 0–80	65±21 0–475

and tundra both in Scandinavia and Russia (on, for example, the Kola Peninsula and in the Ural Mountains). In Fennoscandia this species is distributed very widely south of the Arctic Circle, but rare in Northern Finland; it is not recorded in Northern Sweden, several times recorded in Southern Iceland and only once in Greenland (Palmen 1949, Eason 1970, Jensen & Christensen 2003, Andersson et al. 2005). In Northern Norway it occurs further north than in Northern Sweden, is common in Nordland, but there are no recent records from Finnmark (Bergersen et al. 2006). On the Kola Peninsula, *L. forficatus* was recorded by Palmen (1949) but is not included in more recent faunistic publications. Its presence on the White Sea Islands in the Kandalakša Nature Reserve was queried (Byzova et al. 1986) and it was not included in the "Catalogue of Biota" of the White Sea Biological Station on the north coast of the Karelia Republic, Russia (Tchesunov et al. 2008). During this long-term study, *L. forficatus* was never caught in traps and only one specimen was found in litter collected from a spruce forest at site S1 (67° 35' N). This is the only record that confirms its occurrence on the Kola Peninsula.

In contrast, *L. curtipes* is widespread in natural and anthropogenic ecosystems on the Kola Peninsula. According to our data, this centipede occurs along the latitudinal gradient up to tundra ecosystems along the coast of the Barents Sea. This was also noted by Striganova (1973) at several tundra sites in the vicinity of the Biological Station in Dal'nie Zelency. Lower values of density and biomass of *L. curtipes* in tundra in comparison with northern taiga is in accordance with this centipede being a forest floor species (Zalesskaja 1978, Andersson et al. 2005) and with the latitudinal increase in the harshness of environmental conditions. Foremost, the total sum of the average daily air temperatures (ADAT) is about 1100 °C in the southern part of the Kola

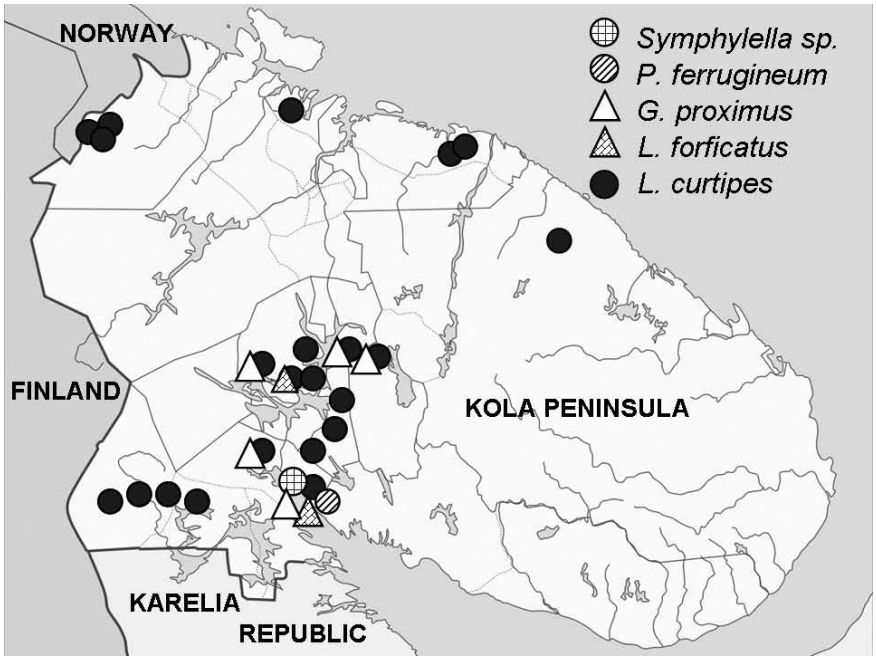


Fig. 4. Map showing the occurrence of myriapods on the Kola Peninsula.

Table 3. Comparison of the numbers of myriapod species recorded in different regions at northern latitudes. Sources of data: [1] Minelli (2013), [2] Golovach (1995), [3] Ghilarov (1986), [4] Starobogatov (1991), [5] Mikhaljova (2004), [6] Shileyko (1995), [7] Skarlato et al. (1994), [8] Palmen (1948), [9] Byzova et al. (1986), [10] Bergersen et al. 2006

	fauna (no. species)	Diplopoda	Chilopoda	Pauropoda	Symphyla
world	~16,000[1]	>12,000	3,149[1]	700	200
former USSR	719	400[2]	315[3]	2[4]	2[4]
Russia	264	180[2] / 103[5]	80[6]	2[7]	2[7]
Kola Peninsula	5	0	4[8,9]	0	19
northern Norway	15[10]	7	8	4	3
Norway	111[1]	49	38	16	8
Sweden	>80[1]	43	32	11	?

Peninsula and decreases to 800–900 °C in the central and western part and to 500–700 °C in the NW, NE and eastern parts of the region. The period with ADAT ≥ +5 °C decreases on the Kola Peninsula from 130 to 90 days, and with ADAT ≥ +10 °C – from 80 to 45 days (Yakovlev 1961, Anonymous 1971, Semko 1982).

A similar density of *L. curtipes* (3.4 ind.m^{-2}) was recorded in birch forest-tundra in Finnish Lapland, in the vicinity of the Kevo Research Station (69° 45' N; Koponen 1987). In sand in the littoral zone (T3) its density (7 ind.m^{-2}) was comparable with that recorded on the White Sea Islands in the Kandalakša Nature Reserve (KRI) (Byzova et al. 1986).

On the Hibiny Mountain Massive, in the high mountain rocky desert with fragmentary moss and lichen cover at an altitude of more than 1000 m a. s. l., the density of *L. curtipes* is higher than in most lowland forest ecosystems. It is noteworthy, that at this altitude air temperatures above 0 °C are recorded on less than 40 days a year and the precipitation is 1200–1500 mm per year compared to 800–900 mm in the forest belts at lower altitudes and the 400–700 mm in the rest of the region (Yakovlev 1961, Anonymous 1971, 2008). The greater numbers of centipedes in mountain ecosystems than on the plains was also recorded for the Northern Ural Mts (Russia) with six species on the plains and only *L. curtipes* in the mountain tundra. In all mountain communities in the Northern Ural Mts *L. curtipes* was abundant (Farzalieva 2008, Farzalieva & Esyunin 2008).

The history of the discovery of this Panpalaearctic species is associated with the polar regions: described for the first time in 1847 by Koch, then ten years later *L. curtipes* was discovered in Finnmark and was the first myriapod recorded in northern Norway (Koch 1847, Palmberg 1866). Later it was reported that *L. curtipes* is common in Sweden, Finland, on the Kola Peninsula and in NE Russia (Palmberg 1866, Tobias 1975). In 1875 *L. curtipes* was recorded as common on Vajgač (Waigatsch) Island, located in the Arctic Ocean on the border between Barents and Kara Seas at 69–70° N and 76–77° E (Stuxberg 1876). At present, the records of *L. curtipes* on Vajgač Island and in Finnmark are the northernmost records for centipedes (Bergersen et al. 2006). It is the only species of myriapods found in arctic Finnish Lapland (69° 45' N): it inhabits mountain birch forest-tundra in 70 km from the Arctic Ocean, where the average annual temperature is +2.5 °C and the lowest temperature, recorded by the local Weather Stations, is –48 °C (Koponen 1987). Of the 28 species of myriapods recorded in the Ural Mts, located in Russia between the two largest East European and West Siberian plains, only *L. curtipes* is common in all mountain provinces (South, Middle, North, Subpolar, and Polar Ural) and also occurs in Arctic tundra (Farzalieva 2008). The ecology of this species on the Kola Peninsula is now well-studied (Zenkova 2003, Zenkova & Petrashova 2003, 2008a, b, Petrashova 2009, 2010, Zenkova et al. 2011).

Summarizing the literature and the present results allow us to conclude that this species is highly successful in colonizing the northern periphery of the area.

Geophilomorph centipedes are rare on the Kola Peninsula. Only two species of European origin are known to occur in the southern part of the region (KRI) and it is evident that they occupy different ecological niches near the northern borders of the area. *P. ferrugineum* is a specialized inhabitant of rocks with various plant associations and the endogeic *G. proximus* prefers meadow soils under grass growing along the coast (Byzova et al. 1986). In accordance with this, *G. proximus* was recorded mainly in the well-developed humus debris layer under herbaceous birch and spruce forests on the S and SE slopes of the Hibiny Mountain Massive. Such communities are also characterized by a high diversity and abundance of earthworms (Zenkova & Rapoport 2013). *P. ferrugineum* was not recorded at any of the sites studied in the northern taiga, forest--tundra and tundra subzones.

In Nordic countries *G. proximus* is the most common geophilid occurring in the far north, especially in Norway, where it inhabits forests, open land and mountains at an altitude of up to 600 m a. s. l. Northern populations are repeatedly recorded as being parthenogenetic races, which vary in body length, number of body segments and pairs of legs (Palmen 1948, Meidell 1969, Barber & Jones 1999, Andersson et al. 2005, Bergersen et al. 2006). This species is not recorded in Finnish Lapland. On the Kola Peninsula it probably occurs only within the forest zone both on plains and in mountains. In this research, the sites where *G. proximus* was recorded, occur at similar latitudes of 67° 34' N on the plain and 67° 38–42' N on the Hibiny Mountain Massive.

P. ferrugineum is a cosmopolitan species which has been introduced into Japan, Taiwan, Hawaii, Juan Fernandez Island and Mexico (Edgecombe & Giribet 2007, Zapparoli & Iorio 2012). Its distribution is determined by its physiological adaptations to arid conditions and ability to survive for long time in sea water. Folkmanova (1950) classifies this species as a steppe chilopod because of its greater resistance to desiccation than other centipedes. In Russia its abundance is greater in dry areas than in wet forests. It is common in open habitats, meadows and pastures than in forests. It is typical for virgin steppes and saline semi-deserts, the first geophilomorph species in natural and man-made sandy substrates (Gilyarov & Folkmanova 1957). In Northern Europe and Asia (Japan, Taiwan, South Korea) it is a littoral (thalassobiont) species widespread on seashores and islands (Barber 2009). Specimens from Southern Finland can survive in sea water for 68–178 days at 6–12 °C and for 24–95 days at 19–27 °C (Palmen & Rantala 1954). In Fennoscandia *P. ferrugineum* is the only species of this genus. It prefers open habitats and is less common than *G. proximus*. In terms of latitude *P. ferrugineum* occurs at approximately 66° N and is not found in the northernmost parts of Norway, Sweden and Finland (Andersson et al. 2005, Bergersen et al. 2006). Rare records of this species on KRI at 66° 34' N, correspond to a warmer temperature regime (namely greater amount of solar radiation and longer frost-free season) in the Kandalakša Nature Reserve than on the rest territory of the Kola Peninsula (Anonymous 1971).

Only one specimen of *Symphylella* sp. juv. was recorded on White Sea Islands studied by Byzova et al. (1986). A map of myriapod occurrences on the Kola Peninsula is presented in Fig. 4.

CONCLUSION

Five species of myriapods are recorded in the literature from the northern-taiga subzone on the Kola Peninsula (*L. curtipes*, *L. forficatus*, *G. proximus*, *P. ferrugineum* and *Symphylella* sp.). This research confirms the occurrence of the first three species in coniferous and deciduous forests. The latitudinal and high-altitude distributions of the species are similar. The panpalearctic polyzonal litter-dwelling lithobiomorph centipede *L. curtipes* is common and wide spread in typical tundra on the coast of the Barents Sea and present in the high-altitude rocky desert on the plateau of the

Hibiny Mountain Massive. It is the only species of myriapod recorded in Finnmark (Norway), subarctic Finnish Lapland, tundra zones in NE Russia, such as those on the Kola Peninsula, Vajgač Island and Polar Ural Mts. The European endogeic geophilomorph centipede *G. proximus* is the second frequency of occurrence after *L. curtipes*. Its distribution on plain and in mountains on the Kola Peninsula is probably limited to the of forest zone. In general, there is a decrease in myriapod diversity the further north one goes, with only a single species *L. curtipes* recorded in the far north of Scandinavia and Russia.

Millipedes were not recorded in permanently frozen soils on the Kola Peninsula although they inhabit similar habitats in Northern Norway, the Karelia Republic. The absence of millipedes and the poor myriapod fauna can be explained in terms of the geographic position of the Kola Peninsula inside the Arctic Circle, it's cool, humid climate and acidic podzol soils with a low content of calcium.

It should be emphasized that these are the results of long-term studies in the most heterogeneous W, NW and SW parts of the Kola Peninsula with complicated relief. The large eastern part of the region remains unknown from a soil-zoological viewpoint because land is inundated, the population is low and lines of communication are poorly developed.

Acknowledgements

This study was supported by the Russian Fund of Fundamental Researches (1997–1999, 2012–2014, 2016); Grants from the Russian Federal Property Fund (2001–2002), Competitive Centre of Fundamental Natural Sciences (2003), Grant of the President of the Russian Federation (2004), Basic Research Programs "Biodiversity" (2007–2009, 2010–2012) and "Live nature: present state and problems of development" (2012–2014) from the Presidium of the Russian Academy of Sciences.

REFERENCES

Andersson G., Meidell B. A., Scheller U., Djursvoll P., Budd G. & Gardenfors U. (eds) 2005: *Mångfotingar*: *Myriapoda*. *The Encyclopedia of the Swedish Flora and Fauna*. Uppsala: Nationalnyckelen ArtDatabanken, 351 pp.

Anonymous 1971: *Atlas Murmanskoj Oblasti* [*Atlas of the Murmansk Region*]. Moskva: Naučno-issledovatelskij geografo-ekonomičeskij institut Leningradskogo gosudarstvennogo universiteta, 33 pp (in Russian).

Anonymous 2008: *Kol'skaâ encykolpediâ* [*Kola Encyclopaedia*]. Apatity: Kol'skij naučnyj centr, Rossijskaâ Akademiâ Nauk, 599 pp (in Russian).

Arinushkina E.V. 1970: *Rukovodstvo po himičeskomu analizu počv* [*Guidance for Chemical Analysis of Soils*]. Moskva: Moskovskij gosudarestvennyj universitet, 490 pp (in Russian).

Barber H. S. 1931: Traps for cave-inhabiting insects. *Journal of the Elisha Mitchell Scientific Society* **46**: 259−266.

Barber A. D. 2009: Littoral myriapods: a review in Myriapoda and Onychophora of the World – Diversity, biology and importance. *Soil Organisms* **81**(3): 735−760.

Barber A. D. & Jones R. E. 1999: A description of Geophilus proximus C. L. Koch, 1847 (Chilopoda, Geophilomorpha). *Bulletin of the British Myriapod Group* **15**: 19−25.

Bergersen R., Olsen K. M., Djursvoll P. & Nilssen A. C. 2006: Centipedes (Chilopoda) and millipedes (Diplopoda) in North Norway. *Norwegian Journal of Entomology* **53**: 23−38.

Byzova Yu. B., Uvarov A. V., Gubina V. G. & Zalesskaya N. T. (eds) 1986: *Počvennye bespozvonočnye belomorskih ostrovov Kandalakšskogo zapovednika* [*Soil Invertebrates of the White Sea Islands of the Kandalakša Reserve*]. Moskva: Nauka, 312 pp (in Russian).

Eason E. H. 1970: The Chilopoda and Diplopoda of Iceland. *Entomologica Scandinavica* **1**: 47−54.

Edgecombe G. D. & Giribet G. 2007: Evolutionary biology of centipedes (Myriapoda: Chilopoda). *Annual Review of Entomology* **52**: 151−170.

Evdokimova G. A., Zenkova I. V. & Pereverzev V. N. 2002: *Biodinamika processov transformacii organičeskogo vešestva v počvah Severnoj Fennoskandii* [*Biodynamic of Transformation Processes of Organic Substances in the Soils of Northern Fennoscandia]*. Apatity: Kol'skij naučnyj centr, Rossijskaâ Ademiâ Nauk, 155 pp (in Russian).

Evdokimova G. A., Zenkova I. V., Mozgova N. P. & Pereverzev V. N. 2005: *Počva i počvennaâ biota v uslovijah zagrâzneniâ florom* [*Soil and Soil Biota under Conditions of the Fluorine Contamination*]. Apatity: Kol'skij naučnyj centr, Rossijskaâ Ademiâ Nauk, 145 pp (in Russian).

Evdokimova G. A., Zenkova I. V., Pereverzev V. N. & Pochilko A. A. 2006: *Kompleksnaâ ekologičeskaâ ocenka territorii predstoâšego stroitelstva zavoda po sžiženiu gaza Štokmanovskogo mestoroždeniâ* [*Integrated Ecological Assessment of a Territory meant for Construction of Liquified Gas Plant Based on the Štokman Field*]. Apatity: Kol'skij naučnyj centr, Russkaâ Ademiâ Nauk, 56 pp (in Russian).

Fairhurst C. P., Barber A. D. & Armitage M. L. 1978: The British myriapod survey – April 1975. *Abhandlungen und Verhandlungen des Naturwissenschaftlichen Vereins zu Hamburg* **21–22**: 129−134.

Farzalieva G. Š. 2008: *Fauna i horologiâ mnogonožek* (*Myriapoda*) *Urala i Priural'â* [*Fauna and Chorology of Myriapods* (*Myriapoda*) *of the Urals and the Cis-Ural Area*]. Unpubl. Thesis. Perm: Perm State University, 24 pp (in Russian).

Farzalieva G. S. & Esyunin S. L. 2008: A review of the centipede (Lithobiomorpha, Henicopidae, Lithobiidae) fauna of the Urals and Cis-Ural area. *Entomological Review* **88**: 598−623.

Folkmanová B. 1950: O zástupcích podčeledi Pachymeriinae Verh. (Geophilomorpha) v našich zemích [About representatives of the subfamily Pachymeriinae Verh. (Geophilomorpha) in Czechoslovakia]. *Věstník Československé Společnosti Zoologické* **14**: 1−14 (in Czech).

Ghilarov M. S. (ed.) 1975: *Metody počvenno-zoologičeskih issledovanij* [*Methods of Soil Zoological Studies*]. Moskva: Nauka, 280 pp (in Russian).

Gilyarov M. & Folkmanova B. 1957: Gubonogie mnogonožky (Chilopoda) stepnoj zony ûgo-vostoka evropejskoj časti SSSR kak pakazateli počvennych uslovij v lesonasaždeniâh [Centipedes (Chilopoda) of the steppe zone of the south-east of the European SSR as indicators of soil conditions in forest plantations]. *Izvestiâ Akademii Nauk SSSR*, *Seriâ Biologičeskaâ* **2**: 211−219 (in Russian).

Golovach S. I. 1995: Raspredelenie i faunogenez dvuparnonogih mnogonožek (Diplopoda) Evrazii [Distribution and faunogenesis of the millipedes (Diplopoda) of Eurasia]. Unpubl. thesis. Moskva: Institut problem èkologii i èvolûcii imeni Severcova, Rossijskaâ Akademiâ Nauk, 28 pp (in Russian).

Jensen D. B. & Christensen K. D. 2003: *The Biodiversity of Greenland – a Country Study*. Nuuk: Greenland Institute of Natural Resources, 165 pp.

Koch C. 1847: System der Myriapoden mit den Verzeichnissen und Berichtigungen zu Deutschlands Crustaceen, Myriapoden und Arachniden. P.: 150. In: Panzer G. & Herrich-Schäffer A. (eds): *Kritische Revision der Insectenfauna Deutschlands III*. Regensburg: Bändchen, 196 pp.

Koponen S. 1987: Počvennaâ fauna subarktičeskogo gornogo berezovogo lesa v Finskoj Laplandii [Soil fauna of the sub-Arctic mountain birch forest in Finnish Lapland]. Pp.: 75–79. In: Krivoluckij D. A. (ed.): *Počvennaâ fauna Severnoj Evropy* [*Soil Fauna of Northern Europe*]. Moskva: Nauka, 175 pp (in Russian).

Koryakin A. S., *Shutova* E. V. & Moskvicheva L. A. 2009: Biodiversity of the Kandalaksha State Nature Reserve: current information, 2009 year. Pp.: 126−129. In: Vasilevskaya N. V. (ed.): *Conservation of Biological Diversity of the Terrestrial and Marine Ecosystems in High Latitude*. *International Scientific-practical Conference*. *Murmansk*, *Russia*, *April 2009*. Murmansk: Murmansk Pedagogical University, 319 pp.

Meidell B. A. 1969: Geophilus insculptus Attems 1895 and Geophilus proximus C. L. Koch 1847 (Chilopoda) in Norway. *Norwegian Journal of Entomology* **16**(1): 9−12.

Mikhaljova E. V. 2004: *The Millipedes* (*Diplopoda*) *of the Asian Part of Russia*. *Pensoft Series Faunistica 39*. Sofia: Pensoft Publishers, 292 pp.

Minelli A. (ed.) 2013: *Chilobase*: *A Web Resource for Chilopoda Taxonomy*. URL: chilobase.bio.unipd.it.

Palmberg J. G. W. 1866: *Bidrag till kännedom om Sveriges Myriapoder*. *Ordningen Chilopoda*. Unpubl. Thesis. Stockholm: Stockholm University, 29 pp.

Palmen E. 1949: The Chilopoda of Eastern Fennoscandia [Soumenkielinen selostus: Itä-fennoscandian jouksujalkaiset]. *Annales Zoologici Societatis Zoologico-Botanicae Fennicae* "*Vanamo*" **13**(4): 1−45.

Palmen E. & Rantala M. 1954: On the life-history and ecology of Pachymerium ferrugineum (C. L. Koch) (Chilopoda, Geophilidae). *Annales Zoologici Societatis Zoologico-Botanicae Fennicae* "*Vanamo*" **16**(3): 1−44.

Pereverzev V. N. 2004: *Lesnye počvy Kol'skogo Polûostrova* [*Forest Soils of the Kola Peninsula]*. Moskva: Nauka, 232 pp (in Russian).

Pereverzev V. N. 2010: Genetičeskie osobennosti počv prirodnyh poâsov Hibinskih gor [Genetic features of soils in altitudinal natural zones of the Hibiny Mountains]. *Eurasian Soil Science* **43**: 509−518 (in Russian).

Pereverzev V. N. 2013: *Počvoobrazovanie na ryhlyh i kristalličeskih porodah v Severnoj Fennoskandii* [*Soil Formation on the Loose and Crystalline Rocks in Northern Fennoscandia*]. Apatity: Kol'skij naučnyj centr, Rossijskaâ Akademiâ Nauk, 158 pp (in Russian).

Petrashova D. A. 2009: Ekologiâ mnogonožki-kostânki Monotarsobius curtipes (C. L. Koch, 1847) na severnoj periferii areala [Ecology of Monotarsobius curtipes (C. L. Koch, 1847) at the northern periphery of its range]. Unpubl. Thesis. Syktyvkar: Institut biologii, Komiskij naučnyj centr, Uralskij filial Rossijskoj Akademii Nauk, 26 pp (in Russian).

Petrashova D. A. 2010: Monotarsobius curtipes kak nespecifičeskij bioindikator zagrâzneniâ počv vybrosamy promyšlennyh predpriâtij [Monotarsobius curtipes as nonspecific bioindicator of soil contaminations by pollutant emissiona from industrial enterprises]. *News of the Samara Scientific Center of RAS* **12**(1): 1947−1950 (in Russian).

Semko A. P. 1982: *Gidrotermičeskij režim počv lesnoj zony Kol'skogo Polûostrova* [*Hydrothermal Regime of Soils in the Forest Zone of the Kola Peninsula*]. Apatity: Kol'skij filial Akademii nauk SSSR, 142 pp (in Russian).

Shileyko A. A. 1995: *Nekotorye problemy sistematiki otrâda Scoloperndromorpha na osnove izučeniâ fauny skolopendr V' etnama* [*Some problems of the systematics of the order Scolopendromorpha based on the research of the scolopendran fauna of Vietnam*]. Unpubl. PhD Thesis. Moskva: Moskovskij gosudarstvennyj universitet, 12 pp (in Russian).

Skarlato O. A., Starobogatov Ya. I., Lobanov A. L. & Smirnov I. S. 1994: Bazy dannyh po zoologičeskoj sistematike i svedeniâ o višših taksonah životnyh [Data bases of zoological systematics and information on the higher taxa of animals]. *Zoologičeskij Žurnal* **73**(12): 100−116 (in Russian).

Starobogatov Y. I. 1991: Filogeniâ i sistema členistonogih (Arthropoda) [Phylogeny and systematics of the arthropods (Arthropoda)]. *Successes of Modern Biology* **3**: 828−839 (in Russian).

Striganova B. R. 1973: Počvennaâ fauna severnogo poberežiâ Kol'skogo Polûostrova [Soil fauna of the northern coast of the Kola Peninsula]. Pp.: 75–84. In: Ghilarov M. S. (ed.): *Èkologiâ počhvennyh bespozvonočnyh* [*Ecology of the Soil Invertebrates*]. Moskva: Nauka, 227 pp (in Russian).

Stuxberg A. 1876: Myriapoda from Siberia and Waigatsch Island collected during the Expedition of Prof. Nordenskiöld 1875. *Annals and Magazine of Natural History*, *Fourth Series* **17**: 306−318.

Tchesunov A. V., Kaljakina N. M. & Bubnova E. N. 2008: *Katalog bioty Belomorskoj biologičeskoj stancii Moskovskogo gosudarstvennogo universiteta* [*A Catalogue of the Biota of the White Sea Biological Station of the Moscow State University*]. Moskva: KMK Scientific Press, 384 pp (in Russian).

Tobias D. 1975: Zur Kenntnis von Lithobius curtipes C. L. Koch (Chilopoda: Lithobiomorpha) in Nordschweden. *Entomologisk Tidskrift* **96**: 24−26.

Zalesskaja N. T. 1978: *Opredelitel mnogonožek-kostânok SSSR* (*Chilopoda*, *Lithobiomorpha*) [*Identification Key of the Lithobiomorph Centipedes of the USSR* (*Chilopoda*, *Lithobiomorpha*)]. Moskva: Nauka, 211 pp (in Russian).

Zapparoli M. & Iorio E. 2012: The centipedes (Chilopoda) of Corsica: catalogue of species with faunistic, zoogeographical and ecological remarks. *International Journal of Myriapodology* **7**: 15−68.

Zenkova I. V. 1999: Sostoânie počvennoj fauny v zone vozdejstviâ kombinata "Severonikel" [The composition of the soil fauna in the impact zone of the Severonikel smelter]. Pp.: 293–310. In: Izrael Y. A., Kalabin G. V. & Nikonov V. V. (eds.): *Antropogennoe vozdejstvie na prirodu Severa i ego èkologičeskie posledstviâ* [*Anthropogenic Impact on the Nature of the North and its Environmental Consequences*]. Apatity: Kol'skij naučnyj centr, Rossijskaâ Akademiâ Nauk, 288 pp (in Russian).

Zenkova I. V. 2000: *Struktura soobŝestv bespozvonočnyh v lesnyh podzolah Kol'skogo Polûostrova* [*Structure of the Invertebrate Communities in the Forest Podzols of the Kola Peninsula*]. Unpubl. PhD Thesis. Petrozavodsk: Petrozavodskij gosudarstvennij universitet, 34 pp (in Russian).

Zenkova I. V. 2003: Dinamika parametrov mezofauny v prirodnyh podzolah Kol'skogo Polûostrova [Dynamics of the mesofauna parameters in natural podzols of the Kola Peninsula]. Pp.: 107−118. In: Kashulin N. A. (ed.): *The Kola Peninsula on the threshold of the third Millennium*: *Ecological Problems*. Apatity: Kola Science Centre, Russian Academy of Sciences, 248 pp. (in Russian).

Zenkova I. V. 2012: Materialy k počvennoj faune trehstoronnego zapovednika Pasvik (Murmanskaâ oblast') [Materials on the soil fauna of the trilateral reserve of Pasvik (Murmansk region)]. Pp.: 313−329. In: Zhigarev I. A. (ed.): *Behavior*, *Ecology and Evolution of Animals*. *Collection of Papers Esenin Râzan' State Unversity* (*Zoology Series* **3**). Râzan': Golos gubernii, 364 pp (in Russian).

Zenkova I. V. & Petrashova D. A. 2003: Harakteristika populacij Monotarsobius curtipes (Chilopoda, Lithobiidae) v lesnyh podzolah Kol'skogo Polûostrova [Characteristics of the Monotarsobius curtipes population (Chilopoda, Lithobiidae) in the forest podzols of the Kola Peninsula]. *Bulletin of Dnipropetrovsk University*, *Biology*, *Ecology* **11**(1): 92−96 (in Russian).

Zenkova I. V. & Petrashova D. A. 2008a: Population structure and dynamics of Monotarsobius curtipes (Myriapoda, Chilopoda) at the northern periphery of the species range. *Russian Journal of Ecology* **39**(6): 425−431.

Zenkova I. V. & Petrashova D. A. 2008b: State of the population of Monotarsobius curtipes in the impact area of aluminium plant. *Contemporary Problems of Ecology* **15**(5): 689−698.

Zenkova I. V., Pozharskaya V. V. & Pokhil'ko A. A. 2011: Altitudinal distribution of soil fauna in the Khibiny Massif. *Eurasian Soil Science* **44**(9): 991−1000.

Zenkova I. V. & Rapoport I. B. 2013: Species richness and high altitude distribution of earthworms in the Khibiny Massive (Murmansk Region). Pp.: 141–151. In: Kasparek M. (ed.): *Advances in Earthworm Taxonomy VI* (*Annelida*: *Oligochaeta*). *6th International Oligochaeta Taxonomy Meeting*, *Palmeira de Faro* (*Portugal*), *April 2013*. Heidelberg: Taylor & Francis, 188 pp.

Yakovlev B. A. 1961: *Klimat Murmanskoj oblasti* [*Climate of the Murmansk Region*]. Murmansk: Murmanskoe knižnoe izdatel'stvo, 199 pp (in Russian).