

THE FIRST RECORD OF THE DWARF PILL MILLIPEDE *GEOGLOMERIS SUBTERRANEA* VERHOEFF, 1908 IN WESTERN GERMANY (DIPLOPODA, GLOMERIDA) AND THE ASSOCIATED MYRIAPODA FAUNA OF THE QUIRRENBACH (SIEBENGEIRGE, NRW)

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ABSTRACT

The Quirrenbach, a forest site at the eastern edge of the Siebengebirge nature region in the southern part of North Rhine-Westphalia, Germany, is covered by an alluvial forest with slopes upwards towards a street. From 2011 to 2017 the site was subject to yearly spring excursions by the arthropod class taught at the Museum Koenig, Bonn, where myriapods were hand-collected and soil samples were extracted via the Berlese method. The site yielded specimens of all classes of the Myriapoda: Symphyla, Pauropoda, Chilopoda and Diplopoda, with one species of Pauropoda, 16 species of Chilopoda and 15 species of Diplopoda being determined to species-level in 2017. In addition to the presence of the pauropod *Trachypauropus cordatus* (Scheller, 1974) in the state, the mainly parthenogenetic dwarf pill millipede *Geoglomeris subterranea* Verhoeff, 1908 was recorded in Berlese samples for the first time. In Germany, less than a handful of old records of the species exist outside of southern Germany. Here we record *G. subterranea* for the first time from Germany's second largest and most populous state, North Rhine-Westphalia. Micro-CT scans were taken to illustrate the species. The small size, cryptic habits, and special collection methods needed to record *Geoglomeris* makes it highly likely that the species is much wider distributed than previously thought.

INTRODUCTION

The knowledge regarding the diversity of the Myriapoda in Germany varies greatly depending on the region, as already pointed out by Decker and Hanning (2011). Thus, species checklists only exist for Eastern Germany (Dunger, 2005), Baden-Württemberg, Bavaria (Spelda, 2006), Thuringia (Reip & Voigtländer, 2009) and North Rhine-Westphalia (Decker & Hanning, 2011; Decker *et al.*, 2015). So far 123 species of Myriapoda (41 Chilopoda, 9 Symphyla, 9 Pauropoda, 64 Diplopoda) are known from North Rhine-Westphalia (NRW) (Decker *et al.* 2015). Here we present a checklist of the Myriapoda found at the Quirrenbach in the Siebengebirge (NRW), including one species new to NRW.

The acquisition of the Drachenfels, which forms the most iconic part of the Siebengebirge, by King Friedrich-Wilhelm III in 1836, to preserve its nature, was the first act of governmental nature conservation in Germany. In 1923 the Naturpark Siebengebirge gained an official conservation status, which made it to the oldest nature reserve in NRW and one of the first nature parks established in Germany (Kottrup, 2016). Today the region is a highly touristic and recreational area. At the eastern border of the Siebengebirge lays the Quirrenbach, which has been sampled since 2011 during the course of a student excursion of the Rheinische Friedrich-Wilhelms University Bonn in corporation with the Zoological Research Museum A. Koenig (ZFMK). The Quirrenbach originates at 260 m above sea level and leads to the Pleißbach after ca. 6 km. Although the Quirrenbach mainly runs through agricultural areas, in some sections it is lined by *Fagus*- and mixed forests. In the past the Quirrenbach has been object to several zoological investigations, which mainly focused on limnic organisms (e.g. Schöll,

1985; Pawlowsky, 1984) but not on the surrounding terrestrial ecosystem, let alone the Myriapoda. Thus, the only Myriapoda recorded previously for the Quirrenbach is *Glomeris tetrasticha* Brandt, 1833, also found during the above mentioned student excursions (Decker & Hanning, 2011). For the Siebengebirge 17 species of Diplopoda and 20 species of Chilopoda were reported by Brocksieper (1973).

The tiny pill millipedes belonging to the genus *Geoglomeris* Verhoeff, 1908 reach a length of 1.5 - 2.5 mm and are characterized by the presence of 10 tergites as opposed to the usual 11 in Glomerida, which are covered with hairs and show micro-sculpturing. Of the six known *Geoglomeris* species only the widespread *G. subterranea* Verhoeff, 1908 is known from Germany, while all other representatives are restricted to France and Italy and show a patchy distribution. The majority of the populations seem to be parthenogenetic and males are only known from three occasions. *G. subterranea* has a number of distribution records in southern France and England, with a handful of sites also known from Ireland, Belgium, Luxemburg, Switzerland, Austria, the Czech Republic and Germany (see Kime & Enghoff, 2011). Only the British populations seem to be reasonably well-researched (e.g. Bockock *et al.*, 1973). Bockock *et al.* (1973) did not only discover that these tiny pill-millipede need several years to mature, but also that they carry very few, just 4 or 5, eggs each year.

From Germany's second largest and most populous western state, NRW, no records exist (Decker & Hanning, 2012; Decker *et al.*, 2015). The only recent findings of *G. subterranea* come from southern Germany (Spelda *et al.*, 2011), as well as from Schengen, Luxemburg, a few meters from the German border (Decker *et al.*, 2015).

Here we report the species for the first time from NRW and use the opportunity to utilize micro-CT scans to study the morphology of such miniscule dwarf pill millipedes.

MATERIAL AND METHODS

From 2011 to 2017 the same area at the Quirrenbach, a small patch of forest at the intersection of Nonnenbergerstraße (L-143) and Humperdinkstraße (50°41'13.6"N 7°17'55.6"E) was sampled by hand-collecting and Berlese extractions. For Berlese extraction leaf-litter and soil were sieved and filled in the Berlese apparatus. All specimens were fixed in 95% ethanol and deposited as vouchers at the Zoological Research Museum A. Koenig.

A μ CT-Scan of *G. subterranea* was performed with a SKYSCAN 1272 in 95% ethanol with the following parameters: source voltage = 40 kV, source current = 200 μ A, exposure = 2928 ms, rotation of 180° in rotation steps of 0.1°, pixel-size = 1 μ m, frame averaging = 7, random movement = 15, flat field correction on, geometrical correction on, no filter. Volume-rendering for habitus-pictures was performed in Drishti (Limaye, 2012).

The geographical distribution was mapped with ArcGIS 10.2.2, using records listed by Reip *et al.* (2012), Decker *et al.* (2015), Desmond Kime (pers. comm., October 11, 2009) and the present study.

RESULTS

Specimens of *G. subterranea* were found in the first soil samples of 2017 after three days of Berlese extraction. A total of three females were found. A second search by hand collecting did not yield any specimens from the same square meter from which the previous soil sample was taken. An additional batch of >40 liters of sieved leaf litter and soil taken from the site yielded after Berlese extraction an additional four female specimens (Figs 1A-C).

From 2011–2017 a single species of Pauropoda, 16 of Chilopoda, and 15 of Diplopoda could be identified at the Quirrenbach site (Table 1). Further specimens of all Myriapod classes were collected but could not be determined to species level.

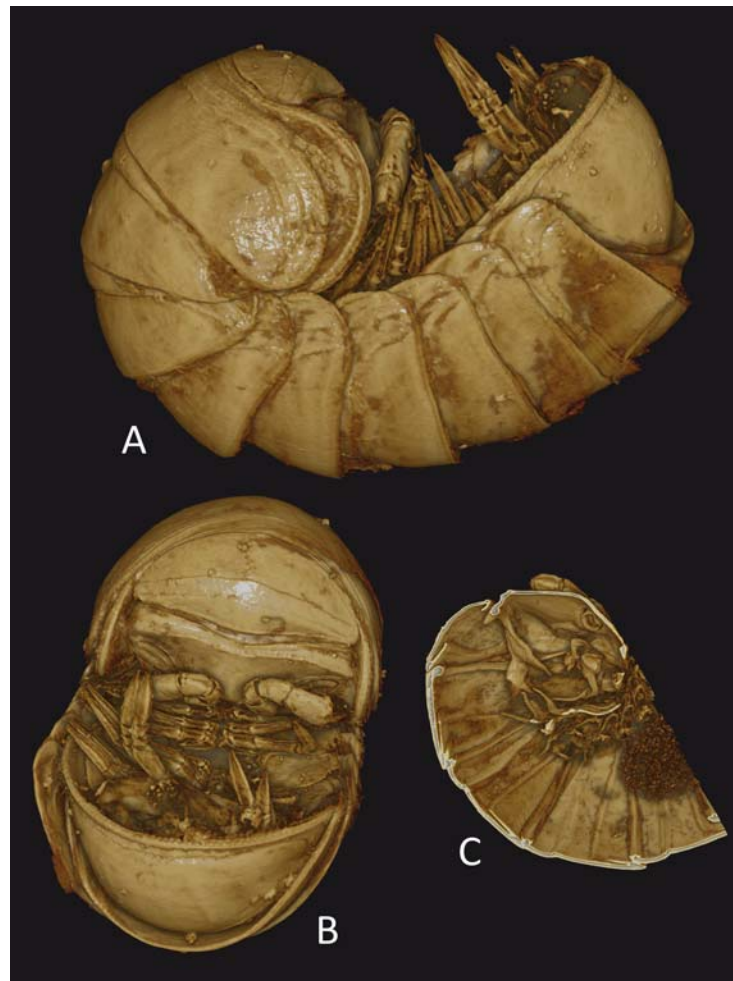


Figure 1: *Geoglomeris subterranea* Verhoeff, 1908 volume-rendering based on μ CT-data.

A) Habitus, lateral view; B) Ventral view; C) Saggital section.

DISCUSSION

In Germany, the few records of *Geoglomeris* in central and eastern Germany are mainly historic with several unsuccessful recollection attempts (Reip *et al.*, 2012). The only known localities where specimens have been found in the last 25 years are in southern Germany. In eastern Germany *G. subterranea* is only known from its type locality (Verhoeff, 1908), where it could never be recollected despite numerous attempts (Reip *et al.*, 2012, own observation by TW). From western Germany only two older records are known: a dubious one from a farming area north of Frankfurt (Klinger, 1992), and several findings in a *Fagus* forest on calcareous soil next to Göttingen (Sprengel, 1986; Scheu, 1990).

Our finding of *G. subterranea* in the area of Bonn and the Siebengebirge area (Fig. 2) is surprising, as the area is one of the best-explored for Diplopoda in the state, recording 61 species of millipedes and centipedes (Decker *et al.*, 2015). At least two PhD theses have been conducted, explicitly dealing with the Myriapoda fauna of the area (Brocksieper, 1976; Fründ & Ruszkowski, 1989), additionally several yearly spring excursions to the area of Quirrenbach, including the taking of Berlese samples, have not yielded any *Geoglomeris* previously.

Table 1: Species of Myriapoda found at Quirrenbach, with corresponding collection number.

MYR = Myriapoda collection of the Research Museum A. Koenig: Only a single voucher number is given for each species, although numerous samples exist.

Pauropoda (1)		
<i>Trachypauropus cordatus</i> (Scheller, 1974)	MYR2515	Only in Berlese samples
Chilopoda (16)		
Geophilomorpha		
<i>Strigamia crassipes</i> (Koch, 1835)	MYR1054	
<i>Strigamia acuminata</i> (Leach, 1815)	MYR1126	
<i>Schendyla nemorensis</i> (Koch, 1835)	MYR1834	
<i>Geophilus flavus</i> (De Geer, 1778)	MYR1832	
Lithobiomorpha		
<i>Lithobius aeruginosus</i> Koch, 1862	MYR1864	
<i>Lithobius agilis</i> Koch, 1857	MYR3297	
<i>Lithobius crassipes</i> Koch, 1862	MYR1862	
<i>Lithobius curtipes</i> Koch, 1847	MYR5352	
<i>Lithobius forficatus</i> (Linnaeus, 1758)	MYR1050	
<i>Lithobius macilentus</i> Koch, 1862	MYR5347	
<i>Lithobius melanops</i> Newport, 1845	MYR1861	
<i>Lithobius microps</i> Meinert, 1882	MYR1121	
<i>Lithobius piceus</i> Koch, 1862	MYR1848	
<i>Lithobius tricuspis</i> Meinert, 1872	MYR2527	
Scolopendromorpha		
<i>Cryptops parisi</i> Brolemann, 1920	MYR1122	
<i>Cryptops hortensis</i> (Leach, 1815)	MYR1844	
Diplopoda (15)		
Glomerida		
<i>Glomeris intermedia</i> Latzel, 1884	MYR1824	
<i>Glomeris marginata</i> Villers, 1789	MYR1365	
<i>Glomeris tetrasticha</i> Brandt, 1833	MYR622	
<i>Geoglomeris subterranea</i> Verhoeff, 1908	MYR6163	Only in Berlese samples
Polydesmida		
<i>Brachydesmus superus</i> Latzel, 1884	MYR1867	
<i>Polydesmus denticulatus</i> Koch, 1847	MYR2222	
<i>Polydesmus angustus</i> Latzel, 1884	MYR2532	
<i>Polydesmus inconstans</i> Latzel, 1884	MYR6160	
Chordeumatida		
<i>Chordeuma sylvestre</i> Koch, 1847	MYR5346	
Julida		
<i>Allajulus nitidus</i> (Verhoeff, 1891)	MYR1677	
<i>Cylindroiulus punctatus</i> (Leach, 1815)	MYR1722	
<i>Julus scandinavus</i> Latzel, 1884	MYR1714	
<i>Tachypodoiulus niger</i> (Leach, 1814)	MYR1716	
<i>Ophiulus pilosus</i> (Newport, 1842)	MYR1718	
<i>Proteroiulus fuscus</i> (Am Stein, 1857)	MYR6221	

This highlights the patchy distribution of *Geoglomeris* species, apparently being restricted to a few square meters.

Hand-collecting by skilled pill millipede collectors did not yield any specimens, despite their known presence in the area. The small size (<2 mm diameter) combined with their cryptic colour (brown) and patchy distribution records make it highly likely that this species was overlooked in a large part of their range. A point further highlighted by the fact that all records in Germany since the 1970s were from Berlese samples, and that the species was not recorded for Austria until 1985 (Gruber, 1985) and the Czech Republic until 2017 (Kocourek *et al.*, 2017).

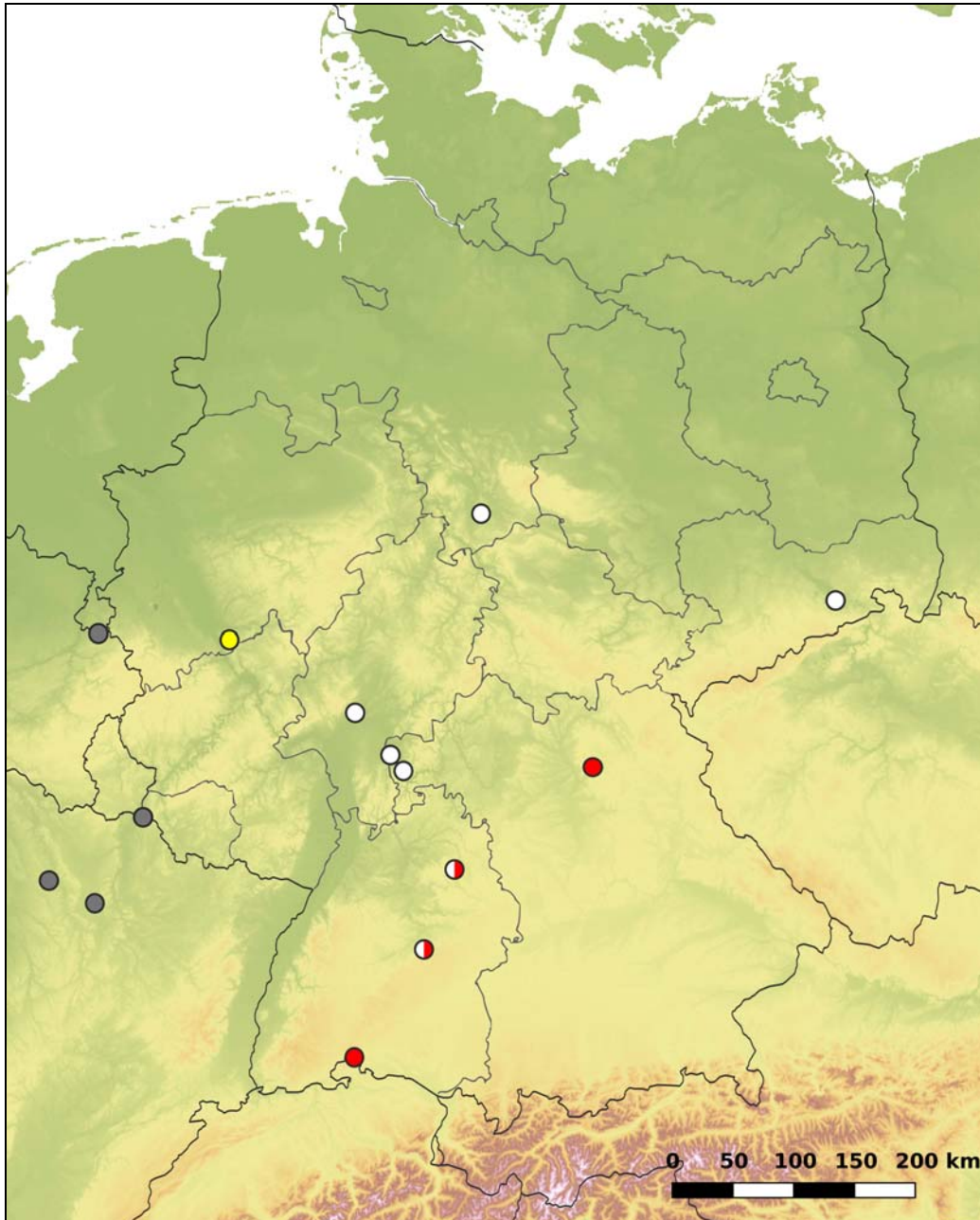


Figure 2: Geographical distribution of *Geoglomeris subterranea* Verhoeff, 1908 in Germany and surrounding areas. The collection site of the present study (Quirrenbach site) is shown in yellow. Records after 1990 are shown in red and previous records in white, while collection sites in neighbouring countries are marked in grey.

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REFERENCES

- Bocock, K. L., Heath, J. & Blower, J. G. (1973) Some observations on the biology of the millipede *Geoglomeris jurassica* Verhoeff, 1915. *Journal of Natural History* **7(6)**: 691-697.
- Brocksieper, I. (1973) *Faunistisch-Ökologische Untersuchungen an Isopoden, Diplopoden und Chilopoden im Naturschutzgebiet Siebengebirge*. Doctoral dissertation, University of Bonn: 73p.
- Brocksieper, I. (1976) Isopoden und Diplopoden des Naturparks Siebengebirge. *Decheniana* **129**: 76-84.
- Decker, P. & Hannig K. (2011): Checkliste der Hundert- und Tausendfüßer (Myriapoda: Chilopoda, Diplopoda) Nordrhein-Westfalens. *Abhandlungen aus dem Westfälischen Museum für Naturkunde* **73(1)**: 3-48.
- Decker, P., Hannig, K., Voigtländer, K. & Wesener, T. (2015) Nachtrag zur Checkliste der Hundert- und Tausendfüßer (Myriapoda: Chilopoda, Diplopoda) und Artenverzeichnis der Zwerg- und Wenigfüßer (Symphyla, Pauropoda) Nordrhein-Westfalens. *Abhandlungen aus dem Westfälischen Museum für Naturkunde* **80**: 5-22.
- Dunger, W. (2005) Myriapods in mid-eastern Germany. *Peckiana* **4**: 35-48.
- Fründ, H.-C. & Ruskowski, B. (1989) Untersuchung zur Biologie städtischer Böden. 4. Regenwürmer, Asseln und Diplopoden. *Verhandlungen der Gesellschaft für Ökologie* **18**: 193-200.
- Gruber, J. (1985) *Geoglomeris subterranea* Verhoeff, 1908, neu für Österreichs Fauna (Diplopoda, Glomerida). *Anzeiger der Österreichischen Akademie der Wissenschaften, mathematisch-naturwissenschaftliche Klasse* **121(7)**: 111-116.
- Kime, R. D. & Enghoff, H. (2011) *Atlas of European millipedes (Class Diplopoda). Orders Polyxenida, Glomerida, Platydesmida, Siphonocryptida, Polyzoniida, Callipodida, Polydesmida. Vol. 1. Fauna Europaea Invertebrata No. 3*, Pensoft, Sofia-Moscow: 282p.
- Klinger, K. (1992) Diplopods and Chilopods of conventional and alternative (biodynamic) fields in Hesse (FRG). *Berichte des naturwissenschaftlich-medizinischen Vereins in Innsbruck, Supplementum*, 243-250.
- Kocourek, P., Tajovsky, K. & Dolejs, P. (2017) New species of millipedes occurring in the Czech Republic: species discovered in the period 2003–2017. *Schubartiana* **6**: 27–30.
- Kottrup K (2016) Die Geschichte des Naturschutzes am Beispiel des Drachenfelsens bei Bonn In: Reinkemeier, P. & Schanbacher, A. (Eds) *Schauplätze der Umweltgeschichte in Nordrhein-Westfalen*. Universität Göttingen: 9-25.
- Limaye, A. (2012) Drishti: a volume exploration and presentation tool. *Developments in X-Ray Tomography VIII* 8506: 85060X.
- Pawlowsky, E. (1984) Limnologische Untersuchung von Fließgewässern des Siebengebirges. *Decheniana*, **137**: 186-202.

- Reip, H. S., Decker, P., Voigtländer, K., Spelda, J., Lindner, E. N. & Hannig, K. (2012) Seltene Myriapoden Deutschlands (Diplopoda, Chilopoda). *Schubartiana* **5**: 49-112.
- Reip, H. S. & Voigtländer, K. (2009) Diplopoda and Chilopoda of Thuringia. *Soil Organisms* **81(3)**: 635-645.
- Scheu, S. (1990). Die saprophage Makrofauna (Diplopoda, Isopoda und Lumbricidae) in Lebensräumen auf Kalkgestein: Sukzession und Stoffumsatz. *Berichte des Forschungszentrums Waldokosysteme, Reihe A* **57**: 302.
- Schöll, F. (1985) Limnologische Untersuchungen der Gewässersysteme Hanfbach und Quirrenbach im südlichen Rhein-Sieg-Kreis. *Decheniana* **138**: 169-181.
- Spelda, J. (2006): Improvements in the knowledge of the myriapod fauna of southern Germany between 1988 and 2005 (Myriapoda: Chilopoda, Diplopoda, Pauropoda, Symphyla). *Peckiana* **4**: 101-129.
- Spelda, J., Reip, H. S., Oliveira Biener, U. & Melzer, R. R. (2011) Barcoding Fauna Bavarica: Myriapoda – a contribution to DNA sequence-based identifications of centipedes and millipedes (Chilopoda, Diplopoda). *ZooKeys* **156**: 123-139.
- Sprengel, T. (1986). Die Doppelfüßer (Diplopoda) eines Kalkbuchenwaldes und ihre Funktion beim Abbau der Laubstreu. Doctoral dissertation, University Göttingen: 113p.
- Verhoeff, K. (1908) Zwei neue Gattungen der Glomeroidea. *Zoologischer Anzeiger* **33(12)**: 413-416.