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Millipedes (Diplopoda) of the Ojców National Park (Poland)

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Abstract: The Ojców National Park (southern Poland) is a small limestone area with outstanding natural values. Until now, there was a lack of information on the spatial distribution of species, their preference of biotopes and microhabitats in the area under study. An interesting question is also the occurrence of native species and the penetration of alien species. Biodiversity can be threatened in such a small, heavily visited by tourists and predominantly forested area, isolated from a similar landscape by agrocenoses and further eroded below the level of the surrounding landscape. Millipedes are soil arthropods, sensitive to calcified soils, stand structure, composition and availability of dead plant biomass, and microclimatic conditions. They are therefore an important reference group of animals for the management of the Ojców NP. In the spring of 2002 and autumn 2004, we carried out detailed inventory research of Diplopoda in the most typical habitats there. We recorded 19 taxa, 2 of which could not be determined to the species level. Together with literature data, a total of 23 species (ca 25% of Polish millipede fauna) are listed here. The occurrence of the moisture-preferring Carpathian mountain species *Polydesmus tatranus* Latzel, 1882 deserves attention. As important species, bound to preserved deciduous and mixed forests with plenty of dead wood, we consider *Glomeris pustulata* (Fabricius, 1781) and *Nemasoma varicorne* C. L. Koch, 1847. The retreat of rare native species as well as invasive aliene species were not recorded. The issue of the unclear nomenclature of the representatives of the genus *Trachysphaera* (Gervaisia) Heller, 1858 occurring in this area and accumulated throughout history is addressed.

Key words: Myriapoda, protected areas, Kraków-Częstochowa Upland, fauna, ecology

INTRODUCTION

Although small, the area of the Ojców National Park (Ojców NP) in southern Poland is an important biocentre. The interest of field biologists in this area, situated close to the city of Kraków, has a long history. Research focused on millipedes (Diplopoda) dates back to the middle of the 19th century (Table 1). In 1854, a prominent Polish naturalist, Antoni Waga, visited the territory of Ojców. In the two-part report (Stronczyński et al. 1855, 1857), he mentioned the discovery of a new species of millipede, tentatively assigned to the genus *Glomeris* Latreille, 1802 as *Glomeris costata*, due to the pronounced transverse dorsal "ribs". In addition to the relatively detailed description of this taxon (on 4 pages in the original text), he also added notes on the occurrence of another 9 species of millipedes in the studied area (Table 1). Soon after this (Waga 1857), he described this taxon as a new genus and species, *Gervaisia costata* (Waga, 1857) (= *Trachysphaera costata* (Waga, 1857), following recent nomenclature). Ślósarski (1883) mentioned 12 species related to given territory, later some of them, such as *Blaniulus guttulatus* (Fabricius, 1798), *Ophyiulus pilosus* (Newport, 1843), were not confirmed by other collectors. Dziadosz (1966) realized the only one millipede inventory in the Ojców NP during the 20th Century and collected 16 species, including the important Carpathian faunistic element, *Polydesmus tatranus* Latzel, 1882, mentioned here for the first time. Nevertheless, few species were repeatedly mentioned by other authors (Stojałowska 1961, Stojałowska & Staręga 1974; Pawłowski & Szeptycki 1977). Pawlowski (2008) mentioned another millipede species previously undocumented from this area, *Cylindroiulus burzenlandicus* Verhoeff, 1907. He

pointed out this species is an example of the occurrence of Carpathian faunistic elements in the Ojców NP. His text was probably based on a compilation of data published by Stojałowska & Staręga (1974) who did not report this species from this exact area. Therefore, we consider of the note by Pawłowski (2008) note to be incorrect information, unsupported by previous or recent field data. In the catalogue of millipedes of Poland (Stojałowska & Staręga 1974), the species are listed according to the main geographical regions of Poland, so the area of the Ojców National Park is not listed separately, and data on the millipede fauna are included in the list of species of the surrounding geomorphological unit, i.e. the Kraków-Wieluń Upland (now Kraków-Częstochowa Upland). In this work, invalid synonyms have also been separated among some species.

Table 1. List of millipede species from the Ojców National Park based on published and current studies.

	Species	[Waga] 1855, 1857, Waga 1857	Ślósarski 1883	Dziadosz 1966	This study
	Polyxenida				
1.	*Polyxenus lagurus* (Linnaeus, 1758)	+	+		+
	Glomerida				
2.	*Glomeris hexasticha* Brandt, 1833		+	+	+
3.	*Glomeris pustulata* (Fabricius, 1781)	+	+[6]	+[6]	+
4.	*Glomeris tetrasticha* Brandt, 1833		+[7]	+[13]	
5.	*Trachysphaera costata* (Waga, 1857)	+	+	+	+
6.	*Trachysphaera schmidtii* Heller, 1858			+[14]	+
	Polyzoniida				
7.	*Polyzonium germanicum* Brandt, 1837	+		+	+
	Julida				
8.	*Blaniulus guttulatus* (Fabricius, 1798)		+[8]		
9.	*Cylindroiulus cf. arborum* Verhoeff, 1928				+
10.	*Enantiulus nanus* (Latzel, 1884)		+[9]	+[15]	+
11.	*Leptoiulus trilobatus* Verhoeff, 1894			+	+
12.	*Megaphyllum projectum* Verhoeff, 1894	+[1]			+
13.	*Nemasoma varicorne* C. L. Koch, 1847			+[16]	+
14.	*Ommatoiulus sabulosus* (Linnaeus, 1758)	+[2]	+[2]	+[17]	+
15.	*Ophyiulus pilosus* (Newport, 1843)		+[10]		
16.	*Unciger foetidus* (C. L. Koch, 1838)	+[3]	+[11]	+	+
17.	*Unciger transsilvanicus* (Verhoeff, 1899)			+[18]	+
.	**Chordeumatida**				
18.	*Mastigona bosniensis* (Verhoeff, 1897)			+[19]	+
19.	*Ochogona* sp.				+
	Polydesmida				
20.	*Polydesmus complanatus* (Linnaeus, 1761)	+	+	+	+
21.	*Polydesmus tatranus* Latzel, 1882	(+)[4]		+	+
22.	*Strongylosoma stigmatosum* (Eichwald, 1830)	+[5]	+[12]	+[12]	+
	Number of species	9 (10)	12	16	19

Explanations: [1] – in [Waga] 1857 as *Iulus dispar,* which according to Stojałowska & Staręga (1974) corresponds to *Megaphyllum projectum kochi*, [2] – as *Iulus sabulosus*, [3] – in [Waga] 1855, 1857 as *Iulus unciger*, [4] – in [Waga] 1855 as *Craspedosoma polydesmoides* (further explanations in the text), [5] – in [Waga] 1955, 1957 as *Polydesmus stigmatosus,* [6] – as *Glomeris pustulata* Latr., [7] – as *Glomeris carpathica* Latzel, [8] – as *Blaniulus guttulatus* Gervais, [9] – as *Julus punctatus* K. Koch, which according to Stojałowska & Staręga (1974) corresponds to *Leptophyllum nanum* (Latzel 1884), [10] – as *Julus falax* Meinert, [11] – as *Julus faetidus* K. Koch, [12] – as *Strongylosoma pallipes* Olivier, [13] – as *Glomeris connexa* C. L. Koch, [14] – as *Trachysphaera acutula* (Latzel), [15] – as *Leptophyllum nanum* (Latzel), [16] – as *Isobates varicornis* (C. L. Koch), [17] – as *Schizophyllum sabulosum* (Linnaeus), [18] – as *Unciger transsilvanicus* Verhoeff, [19] – as *Heteroporatia bosniense* Verhoeff;

In the spring 2002 and autumn 2004 we visited the territory of the Ojców NP and realised detailed collection of soil macrofauna. We focused on species inventory and habitat preference of some arthropod groups. Data dealing with terrestrial isopods and centipedes were already

published separately (Mock et al. 2007; Leśniewska et al. 2011). Except for the short comment on *Trachysphaera costata* (Kania et al. 2005), data on the millipede fauna have not yet been published. In this paper we present a general overview of the millipede fauna, including historical literary data.

METHODS

The millipedes were collected in the spring 2002 and autumn 2004 using visual searching (one sample represented a half an hour searching at the locality) and by sieving of litter and humus layer (sampling area 1 m^2) with entomological sift. Individual specimens were separated from the sifted material individually under the table lamp in every evening after excursions in field station or separated by the Tullgren-Berlese extractor in the laboratory of the first author after finishing of excursions. After fixation in 70% alcohol the millipedes were identified to species level using the Olympus SZ61 stereomicroscope, following keys for Central European millipede fauna, e.g. Stojałowska (1961) and Bielak-Oleksy & Stojałowska (1967/1968) and Schubart (1934). Old revised data are synonymised following Stojałowska & Staręga (1974) – except where the synonymization does not seem adequate to us, what we discuss elsewhere in the study – and nomenclature is actualised according to Sierwald & Spelda (2023). The basic parameters of millipede assemblages were counted, as dominance, constancy (a relative frequence of occurrence per a sample as Cs or per a locality as CL) and sex ratio (summarized portion of adult males, females and juveniles in particular species). The Moticam 580 5.0 MP camera were used in the acquisition of macrophotographs.

STUDY SITES

The Ojców National Park is the smallest one in Poland (21.46 km^2). It represents a beautiful and well-preserved fragment of the natural landscape with a colorful relief conditioned by the geological bedrock of the Upper Jurassic limestones. This formation comprises three main facies: massive limestones, bedded limestones and platy limestones. The massive limestones build up all the picturesque rock-cliffs which are typical of this area (Gradziński et al. 2008). The area is predominantly forested (71%) and belongs to the geomorphologic unit Kraków-Częstochowa Upland (Wyżyna Krakowsko-Częstochowska) with huge limestone tors called monadnocks. Natural complex of rocks, scree slopes, deep valleys and other surface karst phenomena as well as numerous caves and well-preserved forest complexes are the main value of the territory (Alexandrowicz & Alexandrowicz 2004). Due to the influence of tectonics, surface flows and the Pleistocene glacier, the territory is buried below the level of the surrounding upland. Climate-specific environment of temperature inversion shapes a character of local biota with participation of dealpine flora and refuges with cold climate prefering animals, although the highest elevations of the territory do not even rich 500 m a.s.l.

In total 25 surface localities and entrance (twilight zone) of 1 cave were positive for millipede sampling in the most characteristics habitats of the investigated territory. In total 37 millipede-positive subsamples were taken and examined.

List of surface study sites:

1. Prądnik Valley, Alnetum at the foot of the Sukiennice Rocks in the left bank of the river, 280 m a.s.l., sampling in the litter and under the decaying woods, 20 Sep 2004;
2. Prądnik Valley, section near the Skały Panienskie rocky cliff, Salicetum, sampling under the bark of decaying trunk of willow near the stream, ca 330 m a.s.l., 29 Apr 2002;
3. Prądnik Valley, foot of the Sukiennice Rocks, 280–300 m a.s.l., near the Chata Pustelnika cave, Fagetum with limes, sieving of litter, 20 Sep 2004;

4. Prądnik Valley, near fish ponds at the mouth of the Dolina Sąspowska Valley, east slope, 10 m over the tourist track, Fageto-Aceretum, 340 m a.s.l., sieving of litter, 30 Apr 2002;

5. Sąspowska Valley, at the mouth of the Jamki Valley, narrow Saliceto-Alnetum with *Euonymus* sp., *Fraxinus excelsior* surrounded by mesophilous meadows, east exposition, 330–340 m a.s.l., sieving of the litter, 5a: 21 Sep 2004, 5b: 22 Sep 2004;

6. Sąspowska Valley, lower part, left river bank, Alnetum with *Padus racemosa*, *Acer platanoides*, *Salix* sp. and beech, 340 m a.s.l., 6a: sieving of litter, 1 May 2002, 6b: sieving of litter, 22 Sep 2004, 6c: individual sampling, 22 Sep 2004;

7. Sąspowska Valley, middle part, at the Źródło Ruskie Spring, random groups of alders with *Padus racemosa*, *Coryllus avellana*, *Tilia* sp., among mesophilous meadows, 360 m a.s.l., sieving of litter, 2 May 2002;

8. Rusztowa Mt., sunny habitat on the ridge, Carpinetum with *Acer platanoides*, *Corylus avellana, Sambucus nigra*, beech and *Quercus* sp., 450 m a.s.l., sieving of the litter, 1 May 2002;

9. Jamki Valley, Abieto-Fagetum on the left slope with S exp., 370 m a.s.l., sieving of the litter, 21 Sep 2004;

10. Jamki Valley, middle part above the canyon section, dry river-bed, *Fagetum* with *Abies alba* and *Acer* sp., many decaying wood remains, 420 m a.s.l., 10a: sieving of the litter, 2 May 2002, 10b: sieving of litter, 21 Sep 2004, 10c: sampling under the bark of decaying beech bark, 2 May 2002, 10d: sampling under the bark of decaying beech bark, 21 Sep 2004;

11. Jamki Valley, 30–50 m lower then locality no. 10, dry river-bed, Fagetum with *Abies alba*, 390 m a.s.l., E exp., 21 Sep 2004, 11a: sieving of the litter, 11b: individual sampling in the litter;

12. Jamki Valley, Fraxinetum in the lowest part of the valley, 330 m a.s.l., sampling under the stones and logs, 22 Sep 2004;

13. Korytania Valley, in the canyon section, Fagetum with *Carpinus betulus*, at the feet of the walls and in the debris, 330 m a.s.l., sieving of litter, 1 May 2002;

14. Korytania Valley, lower part at the mouth of canyon, at the rocks near dry river-bed, Acereto-Fagetum, 310 m a.s.l., sieving of litter, 1 May 2002;

15. Korytania Valley, the cross to the Skalbania Valley, south slope, Abietum with beech and *Quercus petraea*, 380 m a.s.l., 1 May 2002, 15a: sieving of the litter, 15b: sampling under the bark of decaying fir bark;

16. Malesowe Rocks, small valley north to the rocks, dry river-bed, Lunario-Fagetum, 430 m a.s.l., sieving of litter, 1 May 2002;

17. Rękawica Rock, opposite to the Brama Krakowska, xerothermophilous wood on the SE slope at foot of the rocks (20 m up to the river-bed), *Fagetum* with *Fraxinus excelsior*, *Acer* sp. and *C. avellana*, 340 m a.s.l., sieving of the litter, 2 May 2002;

18. Panieńskie Rocks, upper part, north of the „Igła Deotymy“ rocky tower, foot of the rocks, W exp., Tilio-Aceretum on the debris slope, 360 m a.s.l., sieving of the litter, 21 Sep 2004;

19. Panieńskie Rocks, upper part near the „Igła Deotymy“, top of the rocks, xerotermophilous Querceto-Fagetum with Pinus sylvestris, small layer of the litter and pine-needles, south-west exposition, 380 m a.s.l., sieving (cca 7 x 0.0125 m2), 21 Sep 2004;

20. Panieńskie Rocks, upper part near the „Igła Deotymy“, top of the rocks behind the loc. 19, Pineto-Quercetum bounded by beech forest, 400 m a.s.l., sieving of the litter, 21 Sep 2004;

21. Dzikowiec Gorge, at the mouth to the Jamki Valley, NE slope, Fagetum, 390 m a.s.l., sieving of the litter, 21 Sep 2004;

22. Smardzowicki Gorge, Fagetum with maples in the middle part, in W slope, surroundings of the dry river-bed, 330–340 m a.s.l., sieving of the litter, 20 Sep 2004;

Table 2. Quantitative and distributional data on millipedes in the Ojców National Park (2002, 2004); N – total number of individuals, D – dominance (the highest values are in bold), C – constancy (calculated per a sample as C_S or per a locality as C_L). + is the presence of the species, (+) is the presumed presence of the species based on its general habitat preference (cf. Schubart 1934, Stojałowska 1961).

No.	List of taxa	Localities (samples) (see chapter Methods)	N	Sex ratio: males-females-juveniles	D (%)	C_S (%)	C_L (%)	Main habitats					
						samples n = 37	localities n = 26	*Fagetum*	Riparian woods	*Querceto-Pinetum*	*Carpi-netum*	*Tilio-Aceretum*	Caves
1.	*Polyxenus lagurus*	8,19	3	0-3-0	0,5	5,4	7,7			+	+		
2.	*Glomeris hexasticha*	3,8	7	3-3-1	1,2	5,4	7,7	+		(+)	+		
3.	*Glomeris pustulata*	10b, 10c, 10d	18	8-7-3	3,1	8,1	3,8	+					
4.	*Trachysphaera costata*	8, 10b, 11a, 13, 14, 16, 24a	22	0-15-7	3,8	18,9	26,9	+	(+)		+	+	(+)
5.	*Trachysphaera schmidtii*	2, 3, 4, 5a, 6b, 10a, 10b, 10d, 11a, 13, 14, 16, 17, 21, 24a, 24b	182	28-109-45	31,6	**45,9**	**53,8**	+	+			+	
6.	*Polyzonium germanicum*	5b, 19, 20	4	1-1-2	0,7	8,1	11,5		+	+	(+)	(+)	
7.	*Mastigona bosniensis*	5a, 6b, 18	8	2-4-2	1,4	8,1	11,5		+			+	
8.	*Ochogona* sp.	5a	1	0-1-0	0,2	2,7	3,8		+			(+)	
9.	*Nemasoma varicorne*	10c, 10d, 15n, 23b	74	25-19-30	12,8	10,8	11,5	+		+			
10.	*Cylindroiulus* cf. *arborum*	23b	6	0-0-6	1,0	2,7	3,8			+			
11.	*Leptoiulus trilobatus*	1, 3, 4, 5a, 6a, 6b, 6c, 7, 8, 9, 10a, 10b, 10c, 10d, 11a, 11b, 18, 20, 21, 22, 24a, 24b, 25a	75	22-18-35	13,0	**62,2**	**61,5**	+	+	+	+	+	
12.	*Eantiulus nanus*	3, 15a, 17, 19, 23a	7	0-2-5	1,2	13,5	19,2	+		+			
13.	*Megaphyllum projectum*	1, 3	5	2-0-3	0,9	5,4	7,7	+	+	(+)	(+)		
14.	*Ommatoiulus sabulosus*	19	1	0-0-1	0,2	2,7	3,8			+			
15.	*Unciger foetidus*	3, 5a, 6b, 7, 10a, 14, 18, 22, 23a, 24b, 25a	29	9-13-7	5,0	29,7	**42,3**	+	+	(+)	+	+	
16.	*Unciger transsilvanicus*	1, 3, 7, 8, 20, 23a, 25a, 25b	17	5-10-2	3,0	21,6	26,9	+	+	+	+	(+)	
17.	*Strongylosoma stigmatosum*	3, 4, 5a, 6a, 6b, 6c, 7, 8, 11a, 14, 17, 18, 22, 23a, 24a, 24b, 25a, 25b	68	34-26-8	11,8	**48,6**	**53,8**	+	+		+	+	
18.	*Polydesmus complanatus*	1, 3, 4, 5b, 6a, 6b, 9, 15a, 15b, 25a, 28	16	3-6-7	2,8	29,7	34,6	+	+	(+)	+	+	+
19.	*Polydesmus tatranus*	5a, 10b, 10d, 11a, 11b, 12, 22	33	15-4-14	5,7	18,9	19,2	+	+			(+)	
	Total (19 spp.)		576	157-241-174	100,0	100,0	100,0	12	10 (11)	8 (12)	8 (10)	7 (11)	1 (2)

23. Smardzowicki Gorge, steep SW slope, wood with *Pinus sylvestris*, *Carpinus betulus*, beech, *Abies alba*, 370–380 m a.s.l., 20 Sep 2004, 23a: sieving of the litter, 23b: sampling under the bark of the decaying fir trunk;

24. Stodoliska Gorge, middle part, E exp., foot of the rocks, 320 m a.s.l., Tilio-Aceretum, within the beech woods, 20 Sep 2004, 24a: sieving of the litter, 24b: individual sampling;

25. Stodoliska Gorge, upper part, S exp. slope, 345 m a.s.l., Carpinetum with oaks and beeches, 20 Sep 2004, 25a: sieving of the litter, 25b: individual sampling in litter.

Caves:

26. Pustelnia Cave, 14 m long horizontal cave in forested section of the Jamki Valley, 395 m a.s.l., individual searching of fauna under stones and remains of wood, 21 Sep 2004 (absence of millipedes);

27. Cave shelter, 10 m long horizontal cave in the forested slope of the Dziurawiec Rock, 340 m a.s.l., individual searching under stones and remains of wood, 20 Sep 2004 (absence of millipedes);

28. Wilczy Dół Cave, abyssal cave (length 28 m, depth 8 m) in the Chełmowa Góra Mt., 410 m a.s.l., sieving of litter and sampling on the wet wood remains, both on the bottom of the entrance chasm, 2 May 2002.

RESULTS

Species inventory, assemblage structure and habitat preference

A total of 576 millipede specimens were sampled and 19 taxa (17 to the species level) were identified (Table 2). The order Julida with eight species was the most diversified, followed by Glomerida (four species), Polydesmida (three species), Chordeumatida (two species), Polyxenida and Polyzoniida (one species in each of the orders). Four species were eudominat in the whole analysed assemblage (*Trachysphaera schmidtii* Heller, 1858 > *Leptoiulus trilobatus* (Verhoeff, 1894) ≥ *Nemasoma varicorne* C. L. Koch, 1847 ≥ *Strongylosoma stigmatosum* (Eichwald, 1830)). Only three species occurred at more than half of the sites studied: *L. trilobatus*, *S. stigmatosum* and *T. schmidtii*. The species *Unciger foetidus* (C. L. Koch, 1838) occurred also quite commonly. In contrast, three millipede species were exclusively associated with one study site (*Glomeris pustulata* (Fabricius, 1781), *Ochogona* sp., *Cylindroiulus* cf. *arborum*). The local assemblages varied in species evenness from one to nine species. Site 3 (Dolina Prądnika Valley, at the foot of the rocks Sukiennice) with nine species and site 5 (Dolina Sąspowska Valley, at the mouth of the Jamki Valley) with seven (or nine in two samples in total) were characterised by the most diversified millipede faunas.

The number of species varied at the individual localities representing different types of biotopes studied. In the forested habitats represented by sites under study we found relatively small differences in the species richness. But the preference of subterranean environment (caves) by millipedes contrasts significantly with the attractiveness of surface habitats. The caves of Ojców NP lack a special millipede fauna, and surface species penetrate there only sporadically (Table 2).

Remarkable species

Glomeris pustulata was found only at one site (no. 10), in a beech forest, in crevices under the bark of dead beech trunks and in the litter in a very close surroundings of the trunks. Males and females were equally represented in the samples.

Trachysphaera costata (Fig. 1A) was found sporadically. Except in one plot (no. 8) it was recorded in the co-existence with the much more common congener, *T. schmidtii*. No strict

habitat or microhabitat preference was found for this species, nevertheless forests on skeletal soil or scree slopes are common characteristics of sampling sites. The males were absent.

Trachysphaera schmidtii (Fig. 1B) is another small-bodied representative of the order Glomerida. Females were sampled in a large majority compared to males in the sex ratio of about 3:1 (Table 2). It is characteristic member of assemblages associated with moist to wet forested sites on skeletal soil with well-developed humus horizon.

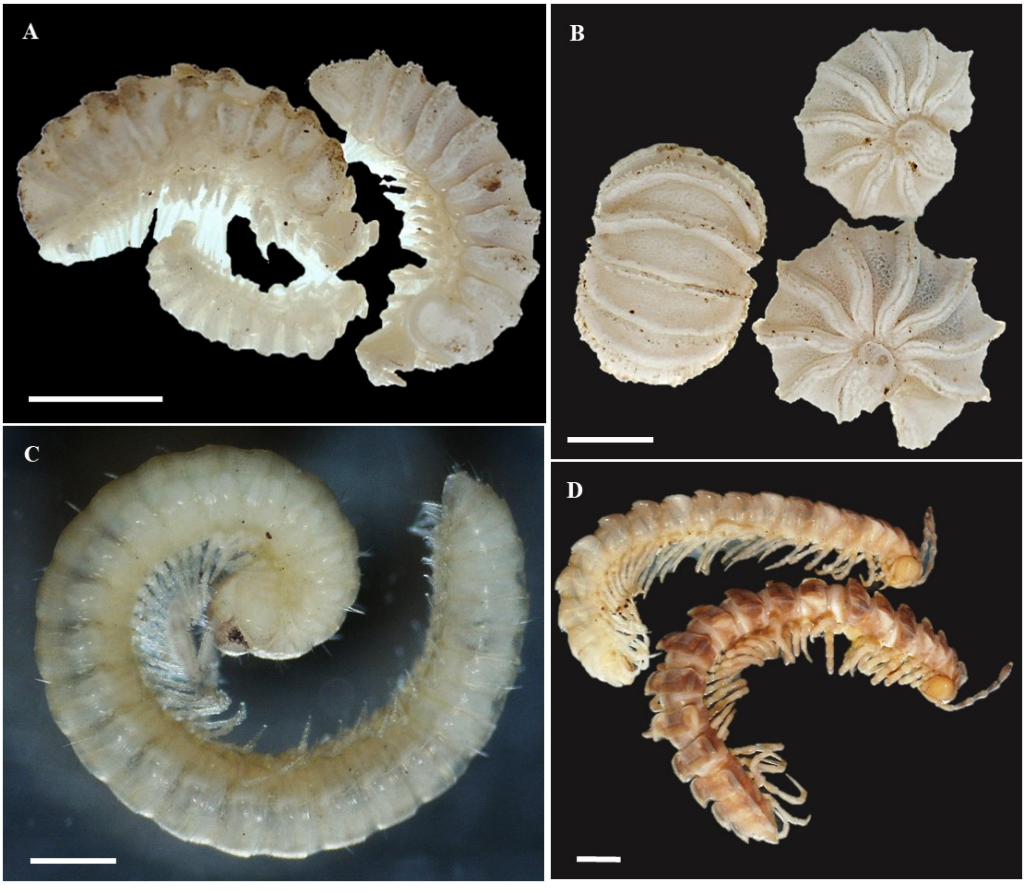

Fig. 1. Some remarkable millipedes from from the Ojców NP; A – *Trachysphaera costata*, two females, and a juvenile (the Jamki Valley). Scale bar: 1 mm; B – *Trachysphaera schmidtii*, two females and a juvenile (the Koritania Valley). Scale bar: 1 mm; C – *Ochogona* sp. (Sąspowska Valley). Scale bar: 1 mm; D – *Polydesmus tatranus tatranus*, female (up) and male (the Sąspowska Valley). Scale bar: 1 mm. All photos by Andrej Mock.

Ochogona sp. (Fig. 1C) showed to be the most interesting new finding. A small (ca 7 mm), pale subadult (?) female specimen with quite a rather low number of ommatidia (11–12) in the triangular occular field and 28 rings with short paranota as a general feature of the specimen. The millipede comes from the site 5 (Dolina Sąspowska Valley), where humid conditions prevail in the riparian vegetation and the millipede assemblage was the richest in species in the investigated area (with 9 species). The specimen was obtained on 21 Sep 2004 while sieving the leaf litter. Even a repeated visit to this site (22 Sep 2004) did not yield more individuals. This is the first representative of the family Craspedosomatidae Gray, 1843 in the Ojców NP.

Nemasoma varicorne is a very tiny millipede, strictly preferring old forests with dead trunks of beech or fir trees, where this species shows an aggregate occurence, with co-existence of both, juveniles and adults. The ratio of males and females was balanced (Table 2).

Cylindroiulus cf. *arborum* was found at a single site (no. 23b) in the microhabitat of dead trunks. A small julid form, with triangular field of ommatidia and telson without prominent process are typical morphological features. They distinguish these specimens from other representatives of the order Julida, found in the Ojców NP. This is the first record of the species in Ojców NP.

Polydesmus tatranus (Fig. 1D) is an inhabitant of wet riparian or beech forests in the study area (sites 5, 10, 11, 12 and 22). The structure of the male gonopods confirmed the affiliation of the specimens to the nominotypical form. The striking colour pattern on the body – an irregular checkerboard distribution of light spots on the dark brown background of the tergites – is unique among representatives of the order Polydesmida in Poland (the coloration partially disappears after fixation in alcohol). The prevalence of males was documented among the adults.

DISCUSSION

The area of the Ojców National Park under nature protection is remarkable in the point of view of millipede diversity, with 23 species documented (Table 1, Fig. 2), what is about 25 % of the Polish millipede fauna (Wytwer 2008). It is about 60% of the species spectrum known from quite well-investigated territory of the whole geomorphological unit Kraków-Częstochowa Upland (Stojałowska & Staręga 1974). The species potential of the Ojców NP is therefore higher than the inventory research has shown so far. The much higher number of millipede species found in the wider surroundings of the national park area is partly done due to the appearance of non-native fauna in the urban greenery of the surrounding urbanized landscape. Thus, the absence of these allochthonous species in the Ojców NP is a positive sign of well-protected local ecosystems; such species have not yet managed to penetrate and settle here. It will be appropriate to verify this claim up to date, as our field data is already two decades old.

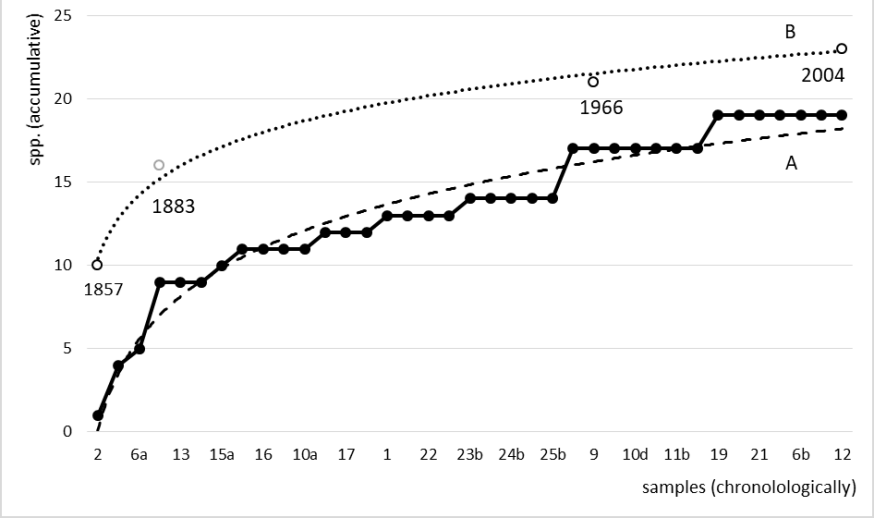

Fig. 2. Species accumulation curves dealing with millipedes of the Ojców NP. Logarithmic trendlines of data are used. Full dots (curve A) are related to data from this study and epmty dots (curve B) are related to historical data (see Table 1).

The species favouring undisturbed forest complexes predominated. Some of them could be considered as relic cold and wet climate preferring fauna with origin in the Carpathians or

spreading through them from southern refuges, such as *Trachysphaera costata*, *T. schmidtii*, *Ochogona* sp., and *Polydesmus tatranus*. The territory of the Ojców NP is at the northernmost border of their total species-area (Kime & Enghoff 2011, 2017, 2021). The occurrence of another species with the center of the species-area in the Carpathians and Bohemian Massif, *Leptoiulus trilobatus*, abundant in the Ojców NP, cross the study area in a northerly direction and riches the Świętokrzyskie Mts. (Jędryczkowski 1987, Kime & Enghoff 2017). Species-rich assemblages dwelling surface habitats contrast strikingly with the absence of millipede fauna in the subterranean enironment. We found only a specimen of forest species, *Polydesmus complanatus*, only in one of the three caves explored, the Wilczy Dół Cave. A series of researches focused on the terrestrial invertebrates in the past also did not documented the occurrence of Diplopoda in the caves in the territory of the Ojców NP (see a review in Kocot-Zalewska & Domagała 2020).

The co-existence (syntopy) of both species of the genus *Trachysphaera*, *T. costata* and *T. schmidtii*, in several habitats typical for landscape of the Ojców NP is interesting from several points of view. These millipede species have a limited dispersion ability indicating historical refugia. Further, they are characterized by the occurrence in a fairly complex environment with preserved forest communities, heterogeneous substrate, a rich layer of litter and humus and dead wood, with an abundance of micro- and macrocaverns (in scree and stream deposits, crevices and caves) with a stable humid and cool climate. Finally, the history of their discovery in the Ojców NP is interesting and is still not quite resolved. First represenative of the genus *Gervaisia* Waga, 1857, *G. costata* was found there during the field work of naturalists in 1854, posted with interesting details in the following report ([Stronczyński et al.] 1855) as *Glomeris costata* nom. nud. Later Waga (in [Stronczyński et al.] 1857) described it as *Glomeris costata* and soon after that he described it as a type species for the new genus, *Gervaisia* Waga, 1857 (Waga 1857). It was only recently Antić et al. (2021) who shed light on the confusion surrounding the description of this species. As already preoccupied (younger homonyme), this generic name was soon replaced by another one, *Trachysphaera* by Heller (1858). This could be the end of the story if some important issues were not left open: doubts about the identity of *T. costata* and the absence of type items and designation of the type locality of the species. The situation is confused by the distribution and frequent co-existence of two species of the genus *Trachysphaera* in most localities in the Ojców NP. Waga ([Stronczyński et al.] 1855, 1857, Waga 1857) did not know this, and he focused his description on the differences between the representatives of the new genus *Gervaisia* Waga, 1857 (in [Stronczyński et al.] 1857) and the genus *Glomeris* Latreille 1802, which are really striking (the size, color, surface of the body are completely different, even in the early stages of development). Waga did not foresee the appearance of two species in the same place. In the original description of *Gervaisia costata* (Waga 1857), including the accompanying drawings, it is not clear which of the two co-existing was observed, respectively, whether only individuals of one of the mentioned species, or a mixed sample of both species were used as types for description. Nevertheless, some features, e.g. general habitus (Fig. 3) and strikingly developed protruding transverse ribs on the dorsal surface – a characteristic used by Waga (in [Stronczyński et al.] 1855, 1857) in establishing of the generic name (*costata* = ribbed, rib-carrying) – are more pronounced in the species *T. schmidtii*, than in *T. costata*. Waga (1857) also mentioned the appearance of a male of a new species, but *T. costata* was recently recorded exclusively in parthenogenetic form with the absence of males in the Ojców NP, similarly as in the entire extra-Ponto-Mediterranean part of its species area (Kime & Enghoff 2017). In a short review (Kania et al. 2005), we gave an incorrect indication of the finding of males in the Ojców NP. This was a typo, because this material consisted exclusively of females. In addition, according to our knowledge and also according Dziadosz (1966), *T. schmidtii* (syn. *Gervaisia* or *Trachyspaera acutula*) is significantly more abundant and frequent in the investigated territory (Table 2, Fig. 4). Thus, formally it will be necessary to decide which species is *T. costata* sensu

Waga (1857), to designate the neotypes and their localization, and to accept all the consequences in the nomenclature within the genus *Trachysphaera* resulting therefrom. *Trachysphaera schmidtii,* according to a new revison based on external morphology by Antić et al. (2021), is a valid name for the form with narrow sharp-edged tergal processes (ribs), distributed north to Alps (mainly the Carpathians and some closely connected regions) as same as in the southern Europe. A separate name, *T. acutula* (Latzel, 1884), was formerly used of the populations north to Alps, what is a younger synonyme of *T. schmidtii* (see the distibution patters in Kime & Enghoff 2017).

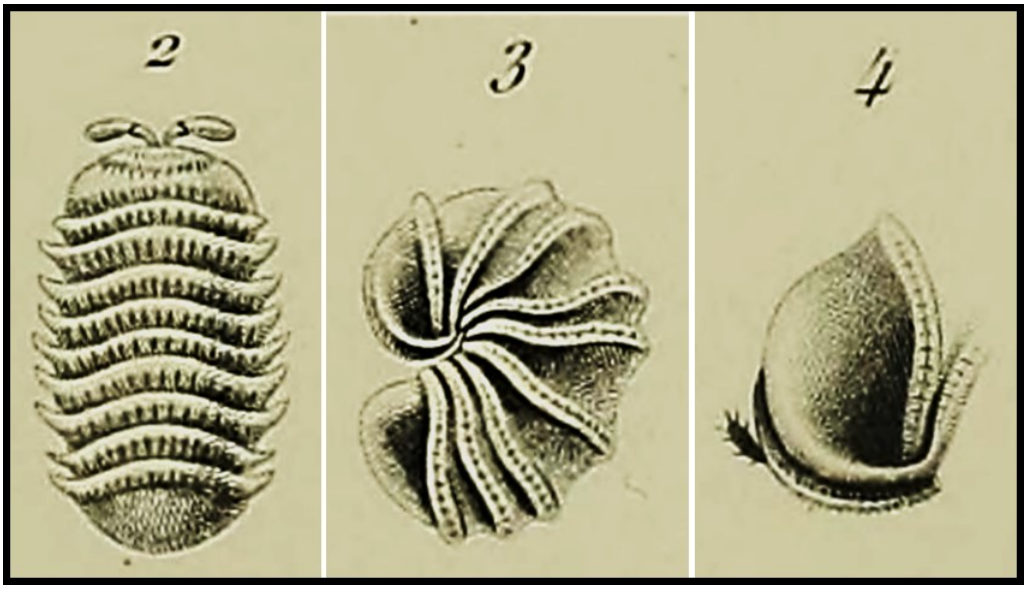

Fig. 3. Original drawings of *Gervaisia costata* Waga, 1857. Modified after Waga (1857).

The identity of the taxon "*Craspedosoma polydesmoides*", reported by Stronczyński et al. (1855) remains unclear. In the work of Stojałowska & Staręga (1974) this find was attributed to the species *Orthochordeuma germanica* (Verhoeff 1892) (a junior synonym of *Mycogona germanica* (Verhoeff, 1892)) although the habitus of *Nanogona polydesmoides* (Leach, 1814), what is a valid name of the millipede from the family Craspedosomatidae, differs evidently from *M. germanica*. The shape of its body with flat tergites extented to pronounced paranota cannot be confused with majority of other millipede species with exeption of the congeneric taxa from some genera as *Craspedosoma* Leach, 1814 or *Chelogona* Cook, 1895 (autochthonous in Poland) or even phylogenetically unrelated *Polydesmus* Latreille, 1802–1803 with convergent morphology. *N. polydesmoides* is a species with Mediterranean to Atlantic distribution avoiding European regions under subcontinental to continental climate (Kime & Enghoff 2021). It has not yet been found in Poland (Wytwer 2008). Using the exclusion method, we assume that Stronczyński et al. (1855) most likely captured at Ojców a representative of the genus *Craspedosoma* Leach, 1814, which may potentially be present here, or the species *Polydesmus tatranus*, which general appearrance and colour pattern could evoke some craspedosomatid millipedes.

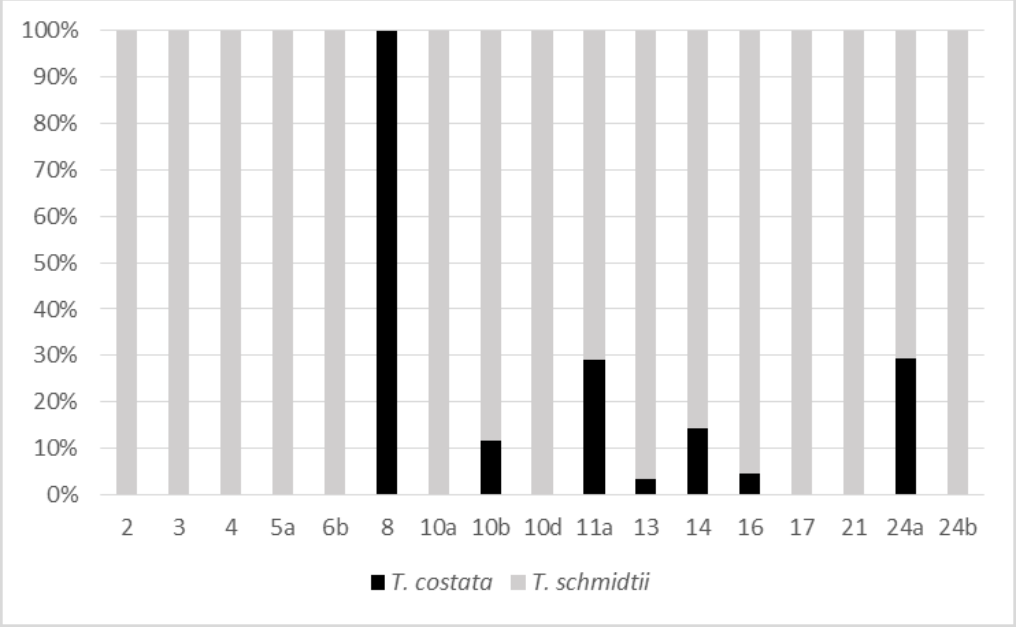

Fig. 4. Co-occurrence and percentage proportion of specimens of particular species of the genus *Trachysphaera* in the asemblages. Numbers of localities, see chapter Study sites.

The finding of a specimen from the genus *Ochogona* Cook, 1895 is interesting. So far, two species of the genus have been known from Poland: *O. caroli* (Rothenbühler, 1900) in the southwestern part of the country and *O. jankowskii* (Jawłowski, 1938), the East Carpathian element on the southeastern edge of the country (Jędryczkowski 1979; Wytwer 2008). None of them have yet been found in the Ojców NP or the surrounding areas (Stojałowska & Staręga 1974, Kime & Enghoff 2021). Their body dimensions and overall habitus are similar. The coloration is usually pale, brownish, without pronounced patterns (Schubart 1934, Wytwer & Golovatch 2004). A sample from the Ojców NP could belong to one of the two species mentioned above. However, smaller body size, lower numbers of body segments and ommatidia could indicate a another species, hitherto unknown in the fauna of Poland. To solve the taxonomic problem, it will be necessary to collect additional adult males providing morphological and molecular markers for precise species determination.

Small representant of the genus *Cylindroiulus* Verhoeff, 1894, preliminary designated as *C.* cf. *arborum* is the first evidence of the genus in the Ojców NP. The circumstances of the finding and habitus are converging to *Cylindroiulus arborum* Verhoeff, 1928. The distribution of *C. arborum* is characterised as Central and Eastern European. The occurrence of this subcorticolous julid in Poland, but even in the rest of its area of distribution, is scattered with isolated point-like occurrence (Stojałowska & Staręga 1974; Jędryczkowski 1987; Kime & Enghoff 2017).

Polydesmus tatranus is a medium-size mountainous hygrophilous representaive of the genus, typical for riparian forest stands in enclosed northern valleys or higher altitudes. The area of distribution of this Carpathian endemic covers north-eastern part of Western Carpathians and north-western part of East Carpathians (nominotypical form) and southern territories of the East Carpathians (*P. tatranus rodnaensis* Verhoeff, 1928) (Stojałowska & Staręga 1974; Kime & Enghoff 2011; Sierwald & Spelda 2023). Both subspecies differ in the shape of male gonopods.

The subspecies affiliation of the population from Ojców NP in the past remained unclear (Dziadosz 1966, Stojałowska & Staręga 1974), nevertheless analysis of recent male specimens, we confirmed the occurrence of the western form, *P. tatranus tatranus* Latzel, 1892. Its occurrence in the Ojców NP is not frequent in general, but characteristic for habitats represented by sampling sites. The territory of the Ojców NP is a rare case of its isolated occurrence outside Carpathians.

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STRESZCZENIE

[**Krocionogi (Diplopoda) Ojcowskiego Parku Narodowego**]

Obszar Ojcowskiego Parku Narodowego stanowi wyjątkowe refugium dla wielu gatunków fauny glebowej, w tym krocionogów. Z uwzględnieniem dotychczasowych danych literaturowych, stwierdzono łącznie 22 gatunki krocionogów, z których dwa nie zostały do końca zidentyfikowane: *Ochogona* sp., *Cylindroiulus* cf. *arborum*. Ta stosunkowo wysoka liczba gatunków czyni badany obszar porównywalnym z takimi górskimi regionami Karpat, jak na przykład Pieniny. To podobieństwo podkreśla występowanie północnokarpackiego węzławca *Polydesmus tatranus*. Najbardziej unikalne zgrupowanie krocionogów stwierdzono w lasach łęgowych, mokrej strefie buczyn z zakumulowanym martwym drewnem i rumoszem skalnym.

Przyjmujemy, że liczba wykrytych gatunków jest definitywna i dotyczy autochtonicznej fauny krocionogów. Jakkolwiek inne obce gatunki moga być spodziewane, szczególnie wokół antropogenicznie zmienionych środowisk. Z uwagi na niewielki rozmiar chronionego obszaru wpływ introdukowanych gatunków na lokalny ekosystem może byc znaczący. Jako że od czasu naszych badań minęło już prawie 20 lat, będzie niezwykle interesującym porównać je z aktualnym stanem krocionogów.

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