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Original Research

Centipede (Chilopoda) Diversity in Forest Habitats of Ojców National Park

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Abstract

Centipedes (Chilopoda) of Ojców National Park [ONP] were the subject of research conducted by Jadwiga Kaczmarek in the 1950s. Using qualitative and quantitative methods in the same area during the period between 2002 and 2004, we collected nearly 900 specimens of Chilopoda. Twenty-two species of centipedes were reported, including three species new to the Kraków-Częstochowa Upland. Currently, 29 species of Chilopoda are known from ONP, which constitutes 53% of the Polish species. The most numerous and most frequently found species include *Lithobius mutabilis* L. Koch, *Lithobius burzenlandicus* Verhoeff, and *Strigamia acuminata* (Leach). The most interesting species is the commonly found Carpathian endemic animal *L. burzenlandicus*. Due to the aforementioned species, the communities of ONP centipedes are of mountainous character.

Forests featuring the greatest diversity of centipede species include beech, hornbeam, and alder forests, while the smallest number of Chilopoda inhabit fir and pine forests of ONP.

The study presents a comparison, an update, and a review of the previous data from ONP. Featuring great diversity of habitats, ONP – from the myriapodological perspective – is a Polish region of exceptional value.

Keywords: Chilopoda, Ojców National Park, biodiversity

Introduction

Ojców National Park (ONP) has protected (since 1956) well-preserved remains of woodland and the open landscape features of the largest karstic area in Poland, the Kraków-Częstochowa Upland. The park, with an area of 21.46 km^2, is the smallest Polish national park. It is located outside the Carpathian range, 16 km north of Kraków. The altitude of ONP ranges between 280 and 481 meters above sea level. The majority of ONP is predominantly covered by beech (*Fagus silvatica*) forests. Rocky sites on the southern and southwestern slopes are of steppe or forest-steppe character with xermophilous conditions. From the botanical point of view, ONP belongs to the most diversified areas in Poland, comparable to the High Tatra Mts. and Pieniny Mts. Relic mountain species of flora and fauna are found in low altitude locations of ONP. Different plant communities and abiotic factors contribute to the high diversity of soil habitats colonized by specific faunas. The area of the park is under strong human impact, therefore knowledge of the present state of the fauna and the changes it has undergone are important [1].

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Table 1. List of centipedes of Ojców National Park based on published and current data.

Species/references	Waga 1855 [2]	Karliński 1882 [3]	Ślósarski 1883 [4]	Kaczmarek 1964 [5]	current work
Clinopodes flavidus C.L.Koch, 1847*	-	+	-	-	-
Geophilus alpinus Meinert, 1870**	-	-	-	+	+
Geophilus electricus (L., 1758)	+	+	+	+	+
Geophilus flavus (De Geer, 1778)***	-	-	-	+	+
Geophilus proximus C.L.Koch, 1847	-	-	+	-	-
Lithobius aeruginosus L.Koch, 1862	-	-	-	+	-
Lithobius agilis C.L.Koch, 1847	-	+	-	+	+
Lithobius borealis Meinert, 1868	-	-	-	-	+
Lithobius burzenlandicus Verhoeff, 1931	-	-	-	-	+
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 (L., 1758)	-	+	+	+	+
Lithobius lapidicola Meinert, 1872 ****	-	+	+	+	+
Lithobius melanops Newport, 1845	-	-	-	-	+
Lithobius microps Meinert, 1868	-	-	-	+	+
Lithobius mutabilis L.Koch, 1862	-	-	-	+	+
Lithobius muticus C.L.Koch, 1847	-	-	-	+	+
Lithobius pelidnus Haase, 1880	-	-	-	+	+
Lithobius piceus L.Koch, 1862	-	-	+	+	+
Lithobius tenebrosus Meinert, 1872*****	-	-	-	+	+
Lithobius tricuspis Meinert, 1872	-	-	-	+	-
Pachymerium ferrugineum (C.L.Koch, 1835)	-	-	-	+	-
Schendyla furcidens Kaczmarek, 1961	-	-	-	+	-
Schendyla nemorensis (C.L.Koch, 1837)	-	-	-	+	+
Strigamia acuminata (Leach, 1815)******	-	-	+	+	+
Strigamia crassipes (C.L.Koch, 1835)*******	-	-	+	+	+
number of species	**1**	**5**	**9**	**24**	**22**

*in Kaczmarek [5] as *Geophilus flavidus,* **in Kaczmarek [5] as *Geophilus insculptus,* ***in Kaczmarek [5] as *Geophilus longicornis,* ****in Kaczmarek [5] as *L. pusillus,* *****in Kaczmarek [5] as *L. nigrifrons,* ******in Kaczmarek [5] as *Scolioplanes acuminatus,* *******in Kaczmarek [5] as *Scolioplanes crassipes*

The first mention of centipedes (Chilopoda) from ONP is from the 19th century in studies by Waga [2], Karliński [3], and Ślósarski [4]. The aforementioned authors reported 11 centipede species from this area (Table 1). Subsequent detailed research on Chilopoda from ONP (using exclusively qualitative methods) was conducted between 1950 and 1961 by Kaczmarek [5], and the author reported the occurrence of 24 centipede species (Table 1).

About 50 years later our research, primarily in the ONP forest areas, yielded a collection of centipedes which enabled the determination of the number and the frequency of species due to the use of quantitative methods.

The main aim of this paper is to update the data on centipedes from ONP forest areas, analyze the data in view of the current knowledge on Chilopoda from Poland, and revise the data included in the study by Kaczmarek [5].

Table 2. The number of specimens of individual species in consecutive sites (1-23).

	Date of collection	September 2004	September 2004	April 2002	September 2004	May 2002 September 2004	May 2002	May 2002	May 2002 Sept. 2004	May 2002 September 2004	September 2004	May 2002	May 2002	May 2002	May 2002	May 2002	May 2002	September 2004	September 2004	September 2004	September 2004	September 2004	September 2004	September 2004	May 2002 September 2004	September 2004	May 2002	September 2004	
	Species/site	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**total**
1	*Geophilus alpinus* E, f, G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	**1**
2	*Geophilus electricus* E, eu, syn, G	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
3	*Geophilus flavus* ES, eu, syn, G	-	-	-	-	1	1	3	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**8**
4	*Lithobius agilis* E, f, L	-	19	1	6	5	1	2	-	2	3	3	2	-	2	1	2	-	-	-	-	4	1	6	-	-	-	**60**
5	*Lithobius borealis* E, eu, L	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
6	*Lithobius burzenlandicus* C, f, moun, L	-	19	3	6	1	9	21	2	12	8	5	15	11	10	9	11	-	2	23	12	10	11	11	-	1	-	**212**
7	*Lithobius curtipes* P, f, L	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
8	*Lithobius cyrtopus* E, f, moun, L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	3	-	-	-	-	-	**4**
9	*Lithobius dentatus* E, f , L	-	-	-	2	-	-	-	-	1	1	-	1	-	1	3	-	-	-	1	-	-	-	-	-	-	-	**10**
10	*Lithobius erythrocephalus* E, eu, L	-	-	1	-	-	1	1	-	2	-	-	-	-	1	4	1	-	-	-	-	-	2	-	1	1	-	**15**
11	*Lithobius forficatus* WP, eu, L	-	1	5	2	8	5	5	-	3	-	1	6	1	1	4	2	1	-	1	2	2	3	1	-	-	-	**54**
12	*Lithobius lapidicola* E, eu, L	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	**2**
13	*Lithobius melanops* E, eu, syn, L	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
14	*Lithobius microps* E, eu, syn, L	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4	-	-	-	-	-	**7**
15	*Lithobius mutabilis* E, f, L	-	14	3	17	44	25	18	3	29	12	12	14	34	25	10	4	-	4	20	11	13	14	8	-	-	-	**334**
16	*Lithobius muticus* E, eu, L	-	-	1	1	-	3	-	-	4	-	3	1	-	-	2	1	-	-	3		1	2	1	-	-	-	**23**
17	*Lithobius pelidnus* E, f, L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	**2**
18	*Lithobius piceus* E, f, L	3	-	2	3	5	1	-	-	1	-	3	3	-	3	6	7	-	-	2	5	1	1	1	-	-	-	**47**
19	*Lithobius tenebrosus* E, f, L	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**2**
20	*Schendyla nemorensis* E, NA, eu, syn, G	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	1	2	-	-	7	-	-	-	-	-	**16**
21	*Strigamia acuminata* E, f, G	1	3	3	6	4	1	3	2	7	20	4	6	1	3	1	1	-	-	4	3	3	2	2	-	1	-	**81**
22	*Strigamia crassipes* E, eu, G	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	**1**
	Total species	**2**	**5**	**8**	**9**	**7**	**10**	**10**	**3**	**11**	**6**	**8**	**10**	**4**	**9**	**9**	**10**	**2**	**3**	**7**	**6**	**10**	**8**	**8**	**1**	**3**	**1**	
	Total specimens	**4**	**56**	**19**	**44**	**68**	**48**	**61**	**7**	**64**	**45**	**32**	**50**	**47**	**47**	**40**	**32**	**2**	**8**	**54**	**35**	**48**	**36**	**31**	**1**	**3**	**1**	**883**
	average density ind/m^2 *		**16**	**19**	**22**	**55**	**48**	**61**	**7**	**29**	**45**	**32**	**50**	**47**	**47**	**40**	**32**		**8**	**54**	**35**	**42**	**36**	**29**				

'*average densities (only where quantitative samples were conducted).

C – Carpathian, E – European, ES – Euro-Siberian, NA – North African, P – Palearctic, WP – West Palearctic, eu – eurytopic, f – forest, moun – mountain, syn – synantropic, G – Geophilomorpha, L – Lithobiomorpha

Table 3. The number of specimens of individual species in the investigated types of forests and caves according to the number of occupied habitats.

Species/habitats	*Fagetum*	*Carpinetum*	*Alnetum*	*Tilio-Aceretum*	*Pinetum*	*Abietum*	*Cave*	Number of habitats	Number of specimens
Lithobius burzenlandicus	118	32	16	22	12	11	1	7	212
Strigamia acuminata	56	5	12	3	3	1	1	7	81
Lithobius forficatus	25	6	15	5	2	1	-	6	54
Lithobius mutabilis	153	26	86	18	17	34	-	6	334
Lithobius erythrocephalus	8	1	1	3	-	-	2	6	15
Lithobius agilis	33	9	11	3	4	-	-	5	60
Lithobius muticus	14	1	4	3	1	-	-	5	23
Lithobius piceus	25	1	12	8	1	-	-	5	47
Geophilus flavus	3	3	2	-	-	-	-	3	8
Lithobius microps	2	-	1	-	4	-	-	3	7
Schendyla nemorensis	1	6	-	-	9	-	-	3	16
Lithobius cyrtopus	-	-	-	1	3	-	-	2	4
Lithobius dentatus	8	-	2	-	-	-	-	2	10
Geophilus electricus	1	-	-	-	-	-	-	1	1
Geophilus alpinus	-	1	-	-	-	-	-	1	1
Lithobius borealis	-	-	1	-	-	-	-	1	1
Lithobius curtipes	-	1	-	-	-	-	-	1	1
Lithobius lapidicola	-	2	-	-	-	-	-	1	2
Lithobius melanops	1	-	-	-	-	-	-	1	1
Lithobius pelidnus	-	-	-	2	-	-	-	1	2
Lithobius tenebrosus	2	-	-	-	-	-	-	1	2
Strigamia crassipes	1	-	-	-	-	-	-	1	1
Total number of species	**16**	**13**	**12**	**10**	**10**	**4**	**3**		
Total number of specimens	**451**	**94**	**163**	**68**	**56**	**47**	**4**		**883**

Materials and Methods

The study was conducted in ONP in spring 2002 and autumn 2004.

Centipedes were collected by means of qualitative and quantitative methods from 26 sites described below. Qualitative methods involved:

a) direct collection of animals from the available microhabitats in which they occur (under tree bark, logs and trunks, in litter, under stones etc.) – by two of us (A.M. and G.K.) for half an hour at each site
b) the qualitative collection of soil samples that were subsequently hand sorted.

Quantitative methods involved the collection of 23 m^2 of litter sieving – in different types of forests. We used a frame (0.25 m × 0.25 m) and an entomological sift (with quadratic eyelets 1 cm × 1 cm). The collected specimens were separated from the sifted material individually, under a table lamp, every evening after an excursion or in a Tullgren-type extractor under laboratory conditions in the Pavol Jozef Šafárik University, Košice.

The information about the type of sample and the collection date is provided below with the description of each site. In total, 6 main types of forests were distinguished (Table 3). Additionally, qualitative samples from two caves were collected (sites 24 and 25).

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 litter and under decaying wood, September 20, 2004.
2. Prądnik Valley, foot of the Sukiennice rocks, 280-300 m a.s.l., foot of the rocks with the "Chata Pustelnika"

cave, sieving of lime and beech litter (1 m^2), September 20, 2004.

3. Prądnik Valley, near fish ponds at the mouth of the Sąspowska Valley, east slope, margin of the forest, *Fageto-Aceretum*, 340 m a.s.l., sieving of litter (1 m^2), April 30, 2002.
4. Sąspowska Valley, at the mouth of Jamki Valley, narrow *Saliceto-Alnetum* with *Euonymus* sp., *Fraxinus excelsior* surrounded by mesophilous meadows, eastern exposure, 330-340 m a.s.l., sieving of the litter (1 m^2), a) September 21, 2004, b) September 22, 2004.
5. Sąspowska Valley, lower part, left river bank, *Alnetum* with *Padus racemosa*, *Acer platanoides*, *Salix* sp. and beech, 340 m a.s.l., a) sieving of litter May 1, 2002, b) September 22, 2004, and c) individual sampling September 22, 2004.
6. Sąspowska Valley, middle part, at the spring Źródło Ruskie, fragmented patches of alders with *P. racemosa*, *Coryllus avellana*, *Tilia* sp. among mesophilous meadows, 360 m a.s.l., sieving of litter (1 m^2), May 2, 2002.
7. Rusztowa Mt., a sunny habitat on the ridge, *Carpinetum* with *Acer platanoides*, *C. avellana*, *Sambucus nigra*, beech and *Quercus* sp., 450 m a.s.l., sieving of litter (1 m^2), May 1, 2002.
8. 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., sieving of litter (1 m^2), September 21, 2004.
9. Jamki Valley, *Fagetum* with *Abies* and *Acer* sp. a) sampling under the bark of decaying beech bark October 21, 2004, b) sieving of litter (1 m^2) May 2, 2002, c) individual sampling May 3, 2002, d) individual sampling May 2, 2002, e) sieving of litter (1 m^2) September 21, 2004.
10. Jamki Valley, 30-50 m lower than location No. 9, dry river-bed, *Fagetum* with *Abies alba*, 390 m a.s.l., E exp., sieving of litter (1 m^2) , September 21, 2004.
11. 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 m^2), May 1, 2002.
12. Korytania Valley, lower part at the mouth of canyon, at the rocks near a dry river-bed, *Acereto-Fagetum*, 310 m a.s.l., sieving of litter (1 m^2), May 1, 2002.
13. Korytania Valley, the cross to the Skalbania Valley, south slope, *Abietum* with beech and *Quercus petraea*, 380 m a.s.l., sieving of litter, May 1, 2002.
14. Malesowe Rocks, a small valley north of the rocks, a dry river-bed, *Lunario-Fagetum*, 430 m a.s.l., sieving of litter (1 m^2), May 1, 2002.
15. Rękawica Rocks, opposite the Brama Krakowska, xerothermophilous wood on the SE slope at the 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 litter (1 m^2), May 2, 2002.
16. Panienskie Rocks, upper part at "Igła Deotymy," the foot of the rocks, W exp., *Tilio-Aceretum* on the debris slope, 360 m a.s.l., sieving of litter (1m^2), September 21, 2004.
17. Panienskie Rocks, upper part at "Igła Deotymy," top of the rocks, xerotermophilous *Querceto-Fagetum* with *Pinus sylvestris*, a small layer of litter and pine-needles, southwestern exposure, 360 m a.s.l., sieving (cca 7 × 0.0125 m^2), September 21, 2004.
18. Panienskie Rocks, upper part at "Igła Deotymy," top of the rocks behind loc. 17, *Pineto-Quercetum* in beech forest, 400 m a.s.l., sieving of litter (1 m^2), September 21, 2004.
19. Dzikowiec Gorge, at the mouth of Jamki, NE slope, *Fagetum*, 390 m a.s.l., sieving of litter (1 m^2), September 21, 2004.
20. 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 litter (1 m^2), September 20, 2004.
21. Smardzowicki Gorge, steep SW slope, wood with *Pinus sylvestris*, *Carpinus betulus*, beech, *Abies alba*, 370-380 m a.s.l., a) sieving of litter (1 m^2) and b) sampling under the bark of a decaying fir trunk, September 20, 2004.
22. Stodoliska Gorge, middle part, E exp. the foot of the rocks, 320 m a.s.l., *Tilio-Aceretum*, within the beech woods, a) sieving of litter (1 m^2), b) individual sampling, September 20, 2004.
23. Stodoliska Gorge, upper part, S exp. slope, 345 m a.s.l., *Carpinetum* with oak and beech, a) individual sampling, May 3, 2002. b) sieving of litter (1 m^2), September 20, 2004.
24. Schronisko nad Tunelem Stromym Cave, 10 m long horizontal cave in the slope of Dziurawiec Mt., 340 m a.s.l., sampling under the stones and on wood remains, September 20, 2004.
25. Wilczy Dół Cave, an abyssal cave (length 28 m, depth 8 m) with two entrances in the Chełmowa Góra Mt., 410 m a.s.l., a) sieving of litter, b) sampling on wet wood remains, both at the bottom, May 2, 2002.

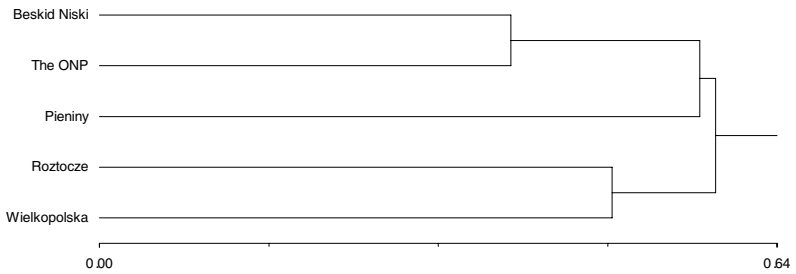

Fig. 1. The similarity of the structure of Chilopoda communities from beech forests in five regions of Poland (similarity measure: Bray and Curtis; cluster method: nearest neighbour).

Table 4. Centipede species composition in beech forests of five areas in Poland.

	Species	OPN (current work)	Pieniny	Wielkopolska	Roztocze	Beskid Niski
1	*Cryptops hortensis* Leach, 1814	-	+	+	-	+
2	*Cryptops parisi* Brolemann, 1920	-	+	-	-	+
3	*Dicellophilus carniolensis* (C.L.Koch,1847)	-	-	-	-	+
4	*Geophilus alpinus* Meinert, 1870	-	-	-	-	+
5	*Geophilus carpophagus* Leach, 1814	-	-	-	-	+
6	*Geophilus electricus* (L., 1758)	+	-	-	-	-
7	*Geophilus flavus* (De Geer, 1778)	+	-	+	+	+
8	*Geophilus proximus* C.L.Koch, 1847	-	+	-	-	-
9	*Geophilus truncorum* (Bergsö, Meinert, 1866)	-	+	+	-	-
10	*Harpolithobius anodus* (Latzel, 1880)	-	+	-	-	+
11	*Lithobius agilis* C.L.Koch, 1847	+	-	+	+	-
12	*Lithobius biunguiculatus* Loksa, 1947	-	+	-	-	-
13	*Lithobius borealis* Meinert, 1868	-	-	+	-	+
14	*Lithobius burzenlandicus* Verhoeff, 1931	+	+	-	-	+
15	*Lithobius crassipes* L.Koch, 1862	-	-	+	-	-
16	*Lithobius curtipes* C.L.Koch, 1847	-	-	+	+	-
17	*Lithobius cyrtopus* Latzel, 1880	-	-	-	+	+
18	*Lithobius dentatus* C.L.Koch, 1844	+	-	-	-	-
19	*Lithobius erythrocephalus* C.L.Koch, 1847	+	-	+	+	-
20	*Lithobius erythrocephlus schuleri* Verhoeff, 1925	-	+	-	-	+
21	*Lithobius forficatus* (L., 1758)	+	+	+	+	+
22	*Lithobius lapidicola* Meinert, 1872	-	+	+	+	+
23	*Lithobius lucifugus* L.Koch, 1862	-	-	-	-	+
24	*Lithobius matici* Prunesco, 1966	-	-	-	-	+
25	*Lithobius melanops* Newport, 1845	+	-	+	+	-
26	*Lithobius microps* Meinert, 1868	+	-	-	+	+
27	*Lithobius mutabilis* L.Koch, 1862	+	+	+	+	+
28	*Lithobius muticus* C.L.Koch, 1847	+	+	-	-	+
29	*Lithobius pelidnus* Haase, 1880	-	+	+	-	-
30	*Lithobius piceus* L.Koch, 1862	+	-	+	+	+
31	*Lithobius silvivagus* Verhoeff, 1925	-	-	-	-	+
32	*Lithobius tenebrosus* Meinert, 1872	+	-	+	-	-
33	*Lithobius tenebrosus setiger* Kaczmarek, 1977	-	+	-	-	+
34	*Lithobius tricuspis* Meinert, 1872	-	-	+	-	-
35	*Schendyla nemorensis* (C.L.Koch, 1837)	+	-	+	+	-
36	*Strigamia acuminata* (Leach, 1815)	+	+	+	+	+
37	*Strigamia crassipes* (C.L.Koch, 1835)	+	+	+	-	+
38	*Strigamia pusilla perkeo* (Verhoeff, 1935)	-	+	-	-	-
39	*Strigamia transsilvanica* (Verhoeff , 1935)	-	+	-	-	+
	Number of species	16	18	19	13	24

Table 5. Dominance structures in individual sites; total dominance and total frequency.

Date of collection	Sept 2004	April 2002	Sept 2004	Sept 2004	May 2002	May 2002	May 2002	Sept 2004	May 2002	Sept 2004	Sept 2004	May 2002	May 2002	May 2002	May 2002	May 2002	May 2002	Sept 2004	Sept 2004	Sept 2004	Sept 2004	Sept 2004	Sept 2004	Sept 2004	Sept 2004		
Species/Site	**2**	**3**	**4**	**4**	**5**	**6**	**7**	**8**	**9**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**18**	**19**	**20**	**21**	**22**	**23**	**Total Dominance**	**Total Frequency**
Geophilus electricus	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	0.12	4.3
Geophilus flavus	-	-	-	-	1.8	2.1	4.9	-	-	-	-	3.1	2	-	-	-	-	-	-	-	-	-	-	0.83	21.7
Lithobius agilis	**33.9**	5.3	**14.3**	11.1	7.3	2.1	3.3	-	1.9	-	6.7	9.4	4	-	4.3	2.5	6.3	-	-	-	9.5	2.8	20.7	6.86	73.9
Lithobius borealis	-	-	-	-	-	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	4.3
Lithobius burzenlandicus	**33.9**	15.8	**14.3**	11.1	1.8	**18.8**	**34.4**	28.6	**22.6**	-	**17.8**	**15.6**	**30**	**23.4**	**21.3**	**22.5**	**34.4**	**25**	**42.6**	**34.3**	**23.8**	**30.6**	**37.9**	24.97	95.7
Lithobius curtipes	-	-	-	-	-	-	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	4.3
Lithobius cyrtopus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.1	-	-	-	7.1	-	-	0.47	8.7
Lithobius dentatus	-	-	5.7	-	-	-	-	-	1.9	-	2.2	-	2	-	2.1	7.5	-	-	1.9	-	-	-	-	1.18	30.4
Lithobius erythrocephalus	-	5.3	-	-	-	2.1	1.6	-	1.9	-	-	-	-	-	2.1	10	3.1	-	-	-	-	5.6	-	1.42	34.8
Lithobius forficatus	1.8	**26.3**	5.7	-	**9.1**	10.4	8.2	-	5.7	-	-	3.1	12	2.1	2.1	10	6.3	-	1.9	5.7	2.4	8.3	3.4	5.8	78.3
Lithobius lapidicola	-	-	-	-	-	-	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.4	0.2	6.7
Lithobius melanops	-	-	-	-	-	-	-	-	-	-	2.2	-	-	-	-	-	-	-	-	-	-	-	-	0.12	4.3
Lithobius microps	-	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.7	9.5	-	-	0.83	13
Lithobius mutabilis	**25.0**	15.8	**31.4**	**66.7**	**72.7**	**52.1**	**29.5**	**42.9**	**52.8**	20	**26.7**	**37.5**	**28**	**72.3**	**53.2**	**25**	**12.5**	**50**	**37.0**	**31.4**	**26.2**	**38.9**	**27.6**	38.82	100
Lithobius muticus	-	5.3	2.9	-	-	6.3	-	-	7.5	-	-	9.4	2	-	-	5	3.1	-	5.6	-	2.4	5.6	3.4	2.72	52.2
Lithobius pelidnus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.3	-	-	-	-	-	-	0.24	8.7
Lithobius piceus	-	10.5	8.6	-	5.5	2.1	-	-	1.9	-	-	9.4	6	-	6.4	**15**	**21.9**	-	3.7	**14.3**	2.4	2.8	3.4	4.97	65.2
Schendyla nemorensis	-	-	-	-	-	-	9.8	-	-	-	-	-	-	-	-	-	-	**25**	-	-	9.5	-	-	1.42	13
Strigamia acuminata	5.4	15.8	**14.3**	11.1	1.8	2.1	4.9	28.6	3.8	80	**44.4**	**12.5**	12	2.1	6.4	2.5	3.1	-	**7.4**	**8.6**	7.1	5.6	-	8.64	91.3
Strigamia crassipes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.1	-	-	-	-	-	-	-	-	0.12	4.3
Total species	**5**	**8**	**9**	**4**	**7**	**10**	**10**	**3**	**9**	**2**	**6**	**8**	**10**	**4**	**9**	**9**	**10**	**3**	**7**	**6**	**10**	**8**	**7**		

(Only where quantitative tests were conducted, only taking into account species present in samples – excluding *G. alpinus* and *L. tenebrosus*).

26. Jamki Valley, lower part, *Fraxinetum*, ca 330 m a.s.l., sampling under stones and logs, September 22, 2004.

In the present study (Table 4, Fig. 1) we compared the species composition of centipedes from ONP beech forests with beech forests from four other regions of Poland well investigated with regard to the Chilopoda. These are the following beech forests: the Lowland beech forest of Wielkopolska (in western Poland), the Upland beech forest in Roztocze (in southeastern Poland) and mountains: in the Pieniny Mts. and in the Lower Beskid (in southern Poland).

Results

A total of 883 individuals from 22 species of Chilopoda were collected (Tables 1-3). The centipedes represent two orders: Lithobiomorpha (16 species) and Geophilomorpha (6 species).

The number of species observed at individual sites ranges from 1 to 11 (Table 2).

The forest with the most abundant number of species is *Fagetum* with *Abies* and *Acer* sp. (site 9), where 11 species of Chilopoda were reported. Ten species were collected from each of the following sites: *Alnetum* (site 6), *Carpinetum* (site 7), *Acereto-Fagetum* (site 12), *Tilio-Aceretum* (site 16), and the mixed forest with *Pinus silvestris*, *Carpinus betulus*, *Fagus silvatica*, and *Abies alba* (site 21).

Two species were collected from the xermophilous *Querceto-Fagetum* (site 17), three species from *Pineto-Quercetum* (site 18), and *Abieto-Fagetum* (site 8), and four species from *Abietum* with beech and *Quercus petrea* (site 13).

The most diversified habitats of ONP in terms of Chilopoda species composition included beech forests (16 species), hornbeam forests (13) and alder forests (12) (Table 3). The smallest number of species is found in fir forests (4) and in caves (3).

Four species are found in all types of forests (*L. burzenlandicus*, *S. acuminata*, *L. forficatus,* and *L. mutabilis*) (Table 3). Species reported exclusively from *Fagetum* include *G. electricus*, *L. melanops*, *L. tenebrosus,* and *S. crassipes*. Species found only in *Carpinetum* include *G. alpinus*, *L. curtipes,* and *L. lapidicola*. *L. borealis* was reported exclusively from *Alnetum*, and *L. pelidnus* was found only in *Tilio-Aceretum*.

The average density of centipedes varied from 7 to 61 specimens/m^2 (Table 2). The highest density was reported from *Carpinetum* – 61 specimens/m^2 (site 7), *Alnetum* – 55 specimens/m^2 (site 5), *Fagetum* – 54 specimens/m^2 (site 19), and *Aceretum* – 50 specimens/m^2 (site 12). The lowest density was reported from *Pineto-Quercetum* – 8 specimens/m^2 (site 18) and *Abieto-Fagetum* – 7 specimens/m^2 (site 8).

Specimens new to ONP include *L. borealis*, *L. burzenlandicus,* and *L. melanops*.

The most numerous and most frequent species of ONP is *L. mutabilis*, whose frequency is 100% and the total dominance is approximately 39% (Table 2). Other numerous and frequent species of the ONP include *L. burzenlandicus*, *S. acuminata*, *L. agilis*, *L. forficatus,* and *L. piceus* (Table 4).

An analysis of the dominance structure in individual forests (Table 5) demonstrates that the most frequently dominant centipede species are *L. mutabilis*, *L. burzenlandicus,* and *S. acuminata*. Sometimes the co-dominant species include *L. forficatus*, *L. piceus*, *L. agilis*, and *S. nemorensis*.

Forest species are dominant in ecological terms (11 – including two mountain species). Six species are eurytopic, and the next five are eurytopic with synanthropic tendencies (Table 2).

From the zoogeographical perspective the majority of the species are European (18) (Table 2).

Discussion

The current list of ONP centipedes includes 29 species (Table 1). This list requires a necessary comment. Numerous changes in the nomenclature of Chilopoda have been introduced during the 50 years since the publication of the study by Kaczmarek [5]. These changes are presented in Table 1.

Recently, the identity of the ONP species described by Kaczmarek as *Schendyla furcidens* [6] has been questioned by Dányi and Wytwer [7], who consider it to be an earlier synonym of *Schendyla nemorensis* (C. L. Koch, 1837).

The occurrence of two species requires some explanation: (1) reported by Kaczmarek [5] as *Lithobius pusillus* (currently *Lithobius lapidicola* Meinert, 1872) and (2) reported by us for the first time in this region and known as *Lithobius burzenlandicus* Verhoeff, 1931. It is highly unlikely that the species *L. lapidicola* – very rare at present – was one of the most frequent and most numerous species of ONP in the 1960s. At the same time it is worth noting that in terms of number and frequency, the position of *L. lapidicola* from the 1960s is currently occupied by *L. burzenlandicus* – a species not reported by Kaczmarek [5] at all. *L. burzenlandicus* is a Carpathian species that is numerous and frequent in the Pieniny Mts., the Lower Beskid Mts., and in the Bieszczady Mts. [8-12]. Since the settlement of ONP by an endemic, Carpathian forest species over the period of the last 50 years seems highly unlikely, the possibility of an erroneous determination of the *L. burzenlandicus* specimens (as *L. pusillus*) was taken into consideration. Only 5 specimens determined by Kaczmarek as *L. pusillus* were found. All of these specimens belong to the species *Lithobius burzenlandicus*. Given the circumstances, it may be assumed that *L. burzenlandicus* has not changed its frequency and the number of occurrence in ONP over the last fifty years. It must be recognized at this point that from the zoogeographical perspective it is *L. burzenlandicus* that is the most interesting ONP species. It is possible that it is a relic of the postglacial cold period in the investigated area.

During the investigations *L. melanops* and *L. borealis* were collected, which had not been previously reported from this area. *L. melanops* is a eurytopic species manifesting a clear synanthropic tendency [13]. Its presence may indicate unfavorable changes connected with human

impact, although it may not necessarily be the case. In many areas of Poland and Europe this species also inhabits forests [13, 14]. The occurrence of *L. borealis* in Poland still remains relatively poorly investigated [15]. However, due to the small number of specimens (one of each), any further conclusions and generalizations regarding possible changes in the character of their occurrence in the park over the last fifty years cannot be made.

The occurrence of four species reported by Kaczmarek [5] and two species reported earlier (Table 1) was not confirmed in our study. However, in Poland these are rare species and their occurrence at present remains possible.

Probably, there are other species of Chilopoda in ONP. However, more intense and long-lasting research conducted throughout the entire year would be necessary in order to report their occurrence. As the authors who had explored the area of the ONP previously, we failed to report any representatives of the order Scolopendromorpha. Given the common occurrence of the species from this order in other regions of Poland it may be assumed that at least one species of the genus *Cryptops* is also present in the ONP forests.

Three species from the ONP, leading in terms of the number and frequency (i.e. *L. mutabilis*, *L burzenlandicus,* and *S. acuminata*) occupy similar positions in the forest communities of Polish mountains – of the Pieniny Mts. [8], the Bieszczady Mts. [9], and the Lower Beskid Mts. [11].

Given the fact that Kaczmarek [5] did not carry out quantitative studies on Chilopoda communities from various types of ONP forests, we are unable to determine with certainty whether any significant changes have taken place over the last fifty years in the structure of the communities – and, in particular, unfavorable changes due to antropopressure.

We collected the material in spring (April-May) and in autumn (September-October). It must be emphasized that given the climatic conditions in Poland, this is the most appropriate period for conducting field investigations on myriapods. In the case of site No. 9 (Table 5), it may seem that the period in which the samples were collected had a fundamental impact on the results. Thus it must be emphasized that this was the only such case. The result may have been connected with a random (chance) difference in the weather conditions. Let us add that in the remaining cases the decisive factor for the results was the diversity of the habitats.

An analysis of centipede density demonstrates that centipedes are most numerous in all types of deciduous forests (which are wet forests at the same time), and that they are least numerous in forests with coniferous trees (Table 2). However, forests with the highest number of centipede species do not always rank first in terms of Chilopoda density. The densities of centipedes in the ONP forests are comparable to the densities of Chilopoda reported from similar types of forests in Europe [15].

In Poland, deciduous forests with the greatest centipede species diversity are usually beech forests. This also applies in the case of ONP. A comparison of the species composition of Chilopoda from ONP beech forests and four other regions of Poland (Table 4) demonstrates that the ONP beech forests are inhabited by two species that were not reported from the areas under comparison – *G. electricus* and *L. dentatus*. The former is frequently found in synanthropic habitats [13], [16], and the latter is a rare forest species. Due to the occurrence of *L. burzenlandicus,* the ONP beech forests resemble mountain beech forests – of the Pieniny and the Beskid Mts. In terms of the structure of the Chilopoda communities from beech forests, the community of ONP Chilopoda is most closely related to the communities from the Lower Beskid beech forests. This fact is clearly illustrated by the dendrogram (Fig. 1). However, owing to the peculiar set of species found in the ONP beech forests, this area remains unique and has proven to be of special value.

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