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Soil mites communities (*Acari: Oribatida, Mesostigmata*) in Kokorycz Natural Reserve (South Western Poland) – a case study

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Abstract: Soil fauna is an important reservoir of biodiversity in forest ecosystems and plays an essential role in these ecosystems. The relationship between soil fauna groups from different trophic levels reflects well the conditions of the ecosystem, which is crucial especially for protected areas such as nature reserves. The aim of the study was to examine for the first time the soil mite (Oribatida and Mesostigmata) community (e.g. abundance, richness, and diversity) in the soil of the Kokorycz Nature Reserve located in the Lower Silesia Region. In 2012, a total of 50 soil samples were collected using a soil corer (10 cm^2) in flood plain forest (40-120 y.o.), dominated by common oak and ash. Overall, 125 species (84 moss mites and 41 predators) were recorded in our study. The most abundant Oribatida were *Conchogneta willmanni, Lauroppia fallax, Oppiella (O.) nova*, and *Rhinoppia subpectinata*. Interestingly, ten oribatid species were recorded from the Lower Silesia Region for the first time. Among Mesostigmata, the most common were *Oodinychus ovalis, Paragamasus runcatellus, Paragamasus vagabundus*, and *Rhodacarus coronatus*. Our study reported high soil fauna species diversity of this reserve and noted that the community is dominated by species typical for mature deciduous forests.

Key words: soil fauna, moss mites, mesostigmatid mites, soil biodiversity

INTRODUCTION

Nature reserves are a vital component of biodiversity conservation (Keiter 2002). Biodiversity conservation is one of the most important topics of forest management (Schmidt 2005). The protection of forests ecosystems requires information about the processes they undergo. Especially, understanding the direction and dynamic of these processes occurring in natural or protected ecosystems may help to better protect ecosystems, however it needs to be looked at from the point of view of species diversity (Skubała 2002). Therefore studies including species richness and diversity in nature reserves, which are valuable natural areas and cover rare ecosystems, are so important.

Oribatida is the most numerous and species rich group in undisturbed soils. They frequently utilize plant organic material (Koukol et al. 2009). In Poland there are ca. 500 known species of moss mites so far (Bogdanowicz et al. 2008). Mesostigmatid mites are one of moderately abundant and species-rich soil animals. In the soil environment, they have a crucial position and mainly feed on another soil mesofauna including oribatid mites, but also nematodes, potworms, small insect larvae and springtails. As soil predators, they are sensitive to changes in the abundance of their prey within the soil food web (Walter and Proctor 1999). So far in Poland ca. 690 species were found (Bogdanowicz et al. 2008).

In opolskie voivodship there are 35 nature reserves, most of them are valuable forests. Especially the flood plain forests are rare and valuable (Nawigator 2012). Kopij (2005) inventoried the birds of the Kokorycz and Dębina Nature Reserves but there is no data about other groups of animals.

The aim of the study was to examine (for the first time) the soil mite (Oribatida and Mesostigmata) community (e.g. abundance, richness, and diversity) in the soil of the Kokorycz Nature Reserve located in the Lower Silesia Region.

MATERIALS AND METHODS

The study was conducted in the Kokorycz Nature Reserve (KNR), located in the south west of Poland, in opolskie voivodship, near Grodków, in the Tułowice Forest District (N 50° 41' 54.09"; E 17° 30' 0.20"). The reserve was established in 2000 to protect natural, old oak-hornbeam forest (*Galio sylvatici-Carpinetum betuli*) near the riverbank of the Nysa Kłodzka River based on Regulation No. P/4/2000 of the Opole Voivode of 10th January 2000 (Rozporządzenie Wojewody Opolskiego P/4/2000 z 10 stycznia 2000). Subsequently changed by Regulation No. 0151/P/5/07 of the Opole Voivode of 8th January 2007 (Rozporządzenie Wojewody Opolskiego

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0151/P/5/07 z 8 stycznia 2007). Kokorycz Nature Reserve, which is located in the Lower Silesia Region (Bogdanowicz et al. 2008), is also part of a larger area protected by the Nature 2000 system named Opolska Dolina Nysy Kłodzkiej (PLH160014 (fig. 1)). The reserve is quite small and covers an area of 44.28 hectares (Kulpiński 2013). Forests in the reserve are classified as flood plain forest and formed by common oak (*Quercus robur* L.), ash (*Fraxinus excelsior* L.), lime (*Tilia* L.), hornbeam (*Carpinus betulus* L.) and alder (*Alnus* Mill.). The herb layer is dominated by rare plants such as *Galanthus nivalis* L., *Corydalis cava* (L.) Schweigg. and Körte, *Hedera helix* L. and *Allium ursinum* L. Soil is classified as brown alluvial soils (Cambic Fluvisols according to IUSS Working Group WRB, 2015) (Kulpiński 2013). The climate of the region is temperate. Mean annual precipitation reached 630 mm, whereas mean annual temperature 8,5°C, and the vegetation period lasts for 227 days (Plan 2014).

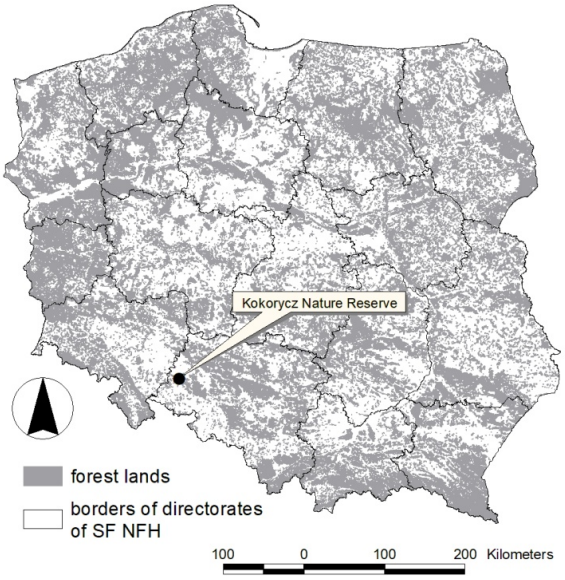

Fig. 1. Localization of the Kokorycz Natural Reserve (SF NFH – State Forests National Forest Holding)

Soil samples were collected twice, in May and September 2012. In total, 50 samples were randomly collected using a steel corer (10 cm2; 5 cm depth in mineral soil) and the area of KNR was completely covered. The samples included the understory vegetation, litter layer, and the upper 5 cm of the mineral soil. The samples were placed in plastic bags and transported in a portable cooler to the laboratory. For seven days the soil fauna was extracted from the soil using Berlese-Tullgren funnels and then preserved in 95% alcohol. Further, oribatid and mesostigmatid mites were selected from samples and classified to species level under a microscope using the identification keys for oribatid mites according to Weigmann (2006), and mesostigmatid mites according to e.g. Micherdziński (1969) and Karg (1993). The names of oribatid mites followed Subias (2004), whereas mesostigmatid mites followed Bogdanowicz et al. (2008). Data analysis was based on abundance, species richness, and Shannon (H') diversity per sample and proportional abundance and frequency of the species. Shannon index of diversity was calculated from the formula: $H' = -\Sigma pilnpi$, where pi is a proportion of individuals found in the i-th species. Species we also classified info five dominance classes (D) as follows: eudominants (D >10%), dominants (5.01-10.00%), subdominants (2.01-5.00%), recedents (1.01-2.00%), subrecedents (<1.01%). Frequency classes are as follow: euconstants C>75.01%, constants (50.01-75.00%), accessory species (25.01-50.00%), accidents (<25.01%).

RESULTS

We identified 3905 mites classified into two suborders: *Oribatida* (3598 ind.) and *Mesostigmata* (307 ind.). The majority of oribatid mites (2640 ind.; 73%) were adults. In total 125 mite species were recorded in our study. Among the reported species, Oribatida mites were represented by 84 species and 2 taxa identified to genus level (individuals incomplete or damaged) (Table 1) whilst Mesostigmata mites by 41 taxa (Table 2). Proportional abundance of four

Table 1. Oribatid mites species in the Kokorycz Natural Reserve

No.	Species Proportional	Abundance(%)	Frequency (%)
1	*Acrotritia duplicata* (Grandjean, 1953)	0.61	22.00
2	*Adoristes ovatus* (Koch, 1839)	0.06	2.00
3	*Allosuctobelba grandis* (Paoli, 1908)	0.08	6.00
4	*Atropacarus striculus* (Koch, 1835)	2.03	48.00
5	*Belba bartosi Winkler*, 1955	0.97	36.00
6	*Belba* sp.	0.03	2.00
7	*Berniniella (B.) bicarinata* (Paoli, 1908)	1.11	18.00
8	*Berniniella (B.) sigma* (Strenzke, 1951)	1.50	20.00
9	*Caenobelba montana* (Kulczyński, 1902)	1.11	32.00
10	*Carabodes (C.) labyrinthicus* (Michael, 1879)	0.08	6.00
11	*Carabodes (C.) ornatus* Štorkán, 1925	0.06	4.00
12	*Ceratoppia bipilis* (Hermann, 1804)	0.03	2.00
13	*Ceratozetella (C.) thienemanni* (Willmann, 1943)	2.06	44.00
14	*Chamobates (C.) pusillus* (Berlese, 1895)	0.06	2.00

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15	*Chamobates voigtsi* (Oudemans, 1902)	1.78	34.00
16	*Conchogneta willmann*i (Dyrdowska, 1929)	6.50	64.00
17	*Ctenobelba pectinigera* (Berlese, 1908)	0.22	12.00
18	*Cultroribula bicultrata* (Berlese, 1905)	0.11	8.00
19	*Damaeus* (Spatiodamaeus) verticillipes (Nicolet, 1855)	0.17	12.00
20	*Damaeus fageti* Bulanova-Zachvatkina, 1957	0.44	12.00
21	*Dissorhina ornata* (Oudemans, 1900)	0.11	6.00
22	*Eremaeus silvestris* Forsslund, 1956	0.03	2.00
23	*Eulohmannia ribaga*i (Berlese, 1910)	0.78	28.00
24	*Eupelops torulosus* (Koch, 1839)	0.03	2.00
25	*Euphthiracarus (E.) monodactylus* (Willmann, 1919)	0.44	2.00
26	*Euzetes globulus* (Nicolet, 1855)	0.39	22.00
27	*Fosseremus laciniatus* (Berlese, 1905)	0.11	4.00
28	*Galumna (G.) lanceata* (Oudemans, 1900)	0.53	20.00
29	*Galumna (G.) obvia* (Berlese, 1914)	0.56	22.00
30	*Gustavia fusifer* (Koch, 1841)	0.72	32.00
31	*Heminothrus (Platynothrus) peltifer* (Koch, 1839)	0.97	22.00
32	*Hermannia (H.) gibba* (Koch, 1839)	0.19	6.00
33	*Hermanniella punctulata* Berlese, 1908	2.22	50.00
34	*Heterozetes palustris* (Willmann, 1917)	0.81	18.00
35	*Hypochthoniella minutissima* (Berlese, 1904)	0.19	4.00
36	*Hypochthonius rufulus* Koch, 1835	2.31	58.00
37	*Lauroppia fallax* (Paoli, 1908)	5.95	26.00
38	*Liacarus (L.) oribatelloides* Winkler, 1956	0.06	4.00
39	*Liochthonius (L.) evansi* (Forsslund, 1958)	0.06	4.00
40	*Liochthonius (L.) simplex* (Forsslund, 1942)	0.11	4.00
41	*Malaconothrus (M.) monodactylus* (Michael, 1888)	0.56	16.00
42	*Metabelba (M.) parapulverosa* Moritz, 1966	0.92	28.00
43	*Micreremus brevipes* (Michael, 1888)	0.06	4.00
44	*Microppia minus minus* (Paoli, 1908)	1.67	40.00
45	*Microtritia minima* (Berlese, 1904)	0.03	2.00
46	*Microzetes petrocoriensis* (Grandjean, 1936)	0.06	4.00
47	*Minunthozetes pseudofusiger* (Schweizer, 1922)	0.33	10.00
48	*Moritzoppia (M.) keilbachi* (Moritz, 1969)	0.22	6.00
49	*Nanhermannia (N.) nana* (Nicolet, 1855)	0.72	22.00
50	*Nothrus anauniensis* Canestrini y Fanzago, 1876	0.44	18.00
51	*Nothrus palustris* Koch, 1839	0.31	18.00
52	*Nothrus silvestris* Nicolet, 1855	0.08	6.00
53	*Ophidiotrichus vindobonensis* Piffl, 1961	0.03	2.00
54	*Oppiella (O.) nova nova* (Oudemans, 1902)	5.89	46.00
55	*Oribatella (O.) quadricornuta* (Michael, 1880)	0.03	2.00
56	*Oribatella (O.) reticulata* Berlese, 1916	0.08	6.00
57	*Oribatula (O.) tibialis* (Nicolet, 1855)	0.22	4.00
58	*Pantelozetes paolii* (Oudemans, 1913)	1.08	22.00
59	*Paratritia baloghi* Moritz, 1966	0.94	14.00
60	*Phthiracarus (Archiphthiracarus) clavatus* Parry, 1979	0.03	2.00
61	*Phthiracarus (P.) laevigatus* (Koch, 1841)	0.06	4.00
62	*Phthiracarus (P.) lentulus* (Koch, 1841)	0.03	2.00
63	*Phthiracarus (P.) longulus* (Koch, 1841)	0.64	24.00
64	*Phthiracarus (Archiphthiracarus) globosus* (Koch, 1841)	0.39	12.00
65	*Porobelba spinosa* (Sellnick, 1920)	0.22	10.00
66	*Protoribates (P.) capucinus* Berlese, 1908	1.11	14.00
67	*Quadroppia (Q.) quadricarinata* (Michael, 1885)	2.08	42.00
68	*Ramusella elliptica* (Berlese, 1908)	0.58	12.00
69	*Ramusella insculpta* (Paoli, 1908)	1.17	24.00
70	*Rhinoppia subpectinata* (Oudemans, 1900)	5.20	42.00
71	*Scheloribates (S.) laevigatus* (Koch, 1835)	0.11	6.00
72	*Scheloribates (S.) pallidulus latipes* (Koch, 1844)	0.06	4.00
73	*Sellnickochthonius cricoides* (Weis-Fogh, 1948)	0.22	6.00
74	*Sellnickochthonius jacot*i (Evans, 1952)	0.36	14.00
75	*Sellnickochthonius rostratus hungaricus* (Balogh, 1943)	0.81	10.00
76	*Sellnickochthonius zelawaiensis* (Sellnick, 1928)	0.06	2.00
77	*Steganacarus (S.) magnus* (Nicolet, 1855)	0.06	4.00
78	*Suctobelbella (S.) acutidens* (Forsslund, 1941)	1.14	40.00
79	*Suctobelbella (S.) longirostris* (Forsslund, 1941)	3.36	42.00
80	*Suctobelbella (S.) subcornigera* (Forsslund, 1941)	0.81	18.00
81	*Suctobelbella (Flagrosuctobelba) alloenasuta* Moritz, 1971	0.94	12.00
82	*Suctobelbella (Flagrosuctobelba) baloghi* (Forsslund, 1958)	0.42	16.00
83	*Synchthonius crenulatus* (Jacot, 1938)	0.08	6.00
84	*Tectocepheus minor* Berlese, 1903	1.81	14.00
	Total	100.0	-

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Table 2. Mesostigmatid mites in the Kokorycz Nature Reserve

No.	Species	Proportional abundance(%)	Frequency (%)
1	*Alliphis halleri* (Canestrini, 1881)	0.65	4.00
2	*Dendrolaelaps cornutus* (Kramer, 1886)	1.30	8.00
3	*Dinychus perforatus* (Kramer, 1886)	1.63	8.00
4	*Eviphis ostrinus* (C.L. Koch, 1836)	3.26	14.00
5	*Gamasellodes bicolor* (Berlese, 1918)	0.33	2.00
6	*Geholaspis mandibularis* (Berlese, 1904)	1.30	8.00
7	*Holoparasitus calcaratus* (C.L.Koch, 1839)	0.65	2.00
8	*Hypoaspis aculeifer* (Canestrini, 1884)	4.23	20.00
9	*Hypoaspis vacua* (Michael, 1891)	1.95	4.00
10	*Leioseius magnanalis* (Evans, 1958)	1.30	6.00
11	*Leptogamasus cuneoliger* Athias-Henriot, 1967	0.98	6.00
12	*Leptogamasus succineus* Witalinski, 1973	2.28	10.00
13	*Microgynium rectangulatum* Trägårdh, 1942	0,98	4,00
14	*Olodiscus minima* (Kramer, 1882)	0.98	6.00
15	*Olodiscus misella* (Berlese, 1916)	3.91	12.00
16	*Ololaelaps placentula* (Berlese, 1887)	0.65	4.00
17	*Ololaelaps veneta* (Berlese, 1903)	0.33	2.00
18	*Oodinychus obscurasimilis* Hirschmann & Zirngiebl-Nicol, 1961	0.33	2.00
19	*Oodinychus ovalis* (C.L. Koch, 1839)	11.40	22.00
20	*Pachylaelaps furcifer* Oudemans, 1903	1.30	8.00
21	*Pachylaelaps longisetis* Halbert, 1915	1.30	6.00
22	*Pachyseius humeralis* Berlese 1910	1.30	8.00
23	*Paragamasus jugincola* Athias-Henriot, 1967	2.28	4.00
24	P*aragamasus runcatellus* (Berlese, 1903)	5.21	28.00
25	*Paragamasus similis* (Willmann, 1953)	0.33	2.00
26	*Paragamasus vagabundus* (Karg, 1968)	6.51	18.00
27	*Pergamasus crassipes* (Linnaeus, 1758)	0.33	2.00
28	*Pergamasus ruehmi* Willmann, 1938	0.98	6.00
29	*Polyaspinus cylindricus* Berlese, 1916	1.95	8.00
30	*Prozercon kochi* Sellnick, 1943	1.95	10.00
31	*Prozercon traegardhi* (Halbert, 1923)	5.86	8.00
32	*Rhodacarellus silesiacus* (Wilmann, 1935)	3.58	16.00
33	*Rhodacarus coronatus* Berlese, 1921	10.10	12.00
34	*Trachytes aegrota* (C.L.Koch, 1841)	1.95	10.00
35	*Trachytes pauperior* Berlese, 1914	0.98	6.00
36	*Urodiaspis tecta* (Kramer, 1876)	0.33	2.00
37	*Veigaia cerva* (Kramer, 1876)	0.65	4.00
38	*Veigaia mollis* Karg, 1971	0.98	4.00
39	*Veigaia nemorensis* (C.L.Koch, 1839)	9.12	34.00
40	*Zercon peltatus* C.L. Koch, 1836	3.91	14.00
41	*Zercon triangularis* C.L.Koch, 1836	0.65	4.00
	Total	100.00	-

species of oribatid mites exceeded 5% of total Oribatida abundance in this study: *C. willmann*i, *L. fallax*, *O. nova*, *R. subpectinata*. Moreover, *C. willmanni* and *H. rufulus* were also the most frequent species. Eleven species were rarely reported from Polish forests: *A. grandis, C. pectinigera, H. palustris, M. petrocoriensis, O. vindobonensis, P. paolii, P. baloghi, P. lentulus, S. longirostris, S. alloenasuta, S. baloghi*. Ten of them were found in the Lower Silesia Region for the first time. The Shannon diversity for Oribatida community reached the value of 3.69.

Among Mesostigmata mites six species i.e. *O. ovalis, P. runcatellus, P. vagabundus P.traegardhi*, *R. coronatus* and *V. nemorensis* reached the proportional abundance of 5%. Additionally, V. nemorensis was the most frequent species in that study. Our study also revealed the presence of relatively rare Mesostigmata species such as *A. halleri, L. cuneoliger, M. rectangulatum O. obscurasimilis, P. ruehmi, T. pauperior* as well as *V. mollis*. Noteworthy, the Shannon diversity for Mesostigmata community reached a value of 3.23.

DISCUSSION

Our study revealed higher species richness (84 species; Table 1) of oribatid mites found in the area of KNR, when compared to other oak (50 to 55 species rich) forest stands (Zaitsev and Wolters 2006). It is difficult to compare our results with other studies as there is a lack of studies conducted in flood plain forests in Europe. Among reported species, *A. grandis* was previously reported from the Upper Silesia region (Katowice, Parkowe Nature Reserve and Śrubita Nature Reserve) from mixed coniferous and broadleaved forest (Olszanowski et al. 1996, Skubała and Gurgul 2011, Skubała and Marzec 2013). Moreover, *C. pectinigera* which is an European species, was noted so far only in western Poland (Bielinek at Oder Nature Reserve, Słomowo Nature Reserve and

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Sudety Mointains) (Olszanowski et al. 1996). This species prefers dry forests and meadows (Weigmann 2006). Additionally, *H. palustris* known as palearctic species living in wet habitats, was recorded also form two localities Koźle at Oder (Olszanowski et al. 1996) and Pomerania and Brodnica Lakeland (Seniczak 2011a). *M. petrocoriensis* was found only once in Poland near Ojców and its habitat is not clear (Olszanowski et al. 1996). *O. vindobonensis* was found twice in the Pod Rysianką Nature Reserve (Skubała 1992) and Śrubita Nature Reserve (Skubała and Gurgul 2011) – both in the Żywiec Beskids Mountains, in mixed forest. Pantelozetes paolii was found only twice in the Upper Silesia Region and in Żywiec Beskids (Olszanowski et al. 1996). *P. paolii* lives in fresh and wet forests (Weigmann 2006). So far, khas only been found in one location in Poland - in spruce deadwood in the Babia Góra National (Skubała and Maślak 2010). *P. lentulus* was found only in lowlands: the Pomerania Lake District Region, Podlasie and Białowieża Forest in adler forest (Niedbała 2008). Only from the Pomerania Lake District is also known *S. longirostri* (Olszanowski 1996, Seniczak 2011b, Seniczak et al. 2019). This species lives in peatbogs. *S. alloenasuta* was found twice: in Bielinek at Oder Nature Reserve (Pomerania Lake District) and in the Upper Silesia Region in dry forests (Olszanowski et al. 1996). *S. (F.) baloghi* was found in Krakowsko-Częstochowska Upperland (in Bukowo and Parkowe Nature Reserve) in beech forest (Olszanowski et al. 1996, Skubała and Marzec 2013).

Generally, our study revealed the presence of 41 species of mesostigamatid mites. Although the total number seemed to be relatively low, rarely more than 60 species are recorded at a single site (Ruf and Beck 2005). Among the recorded species, the majority were Gamasina (32 taxa), whilst Uropodina were represented by nine species. The species richness of Uropodina was lower than noticed by Napierała et al. (2009), who reported 28 species from soil environments of the oak-hornbeam forest. Additionally, *O. ovalis* reach the highest proportional abundance (D = 11.4; Table 2), among Uropodina in our study, whilst other uropodid species were less abundant (D<3.91). These results may suggest that environmental conditions are suitable for these mite's in this reserve which is in line with our previous study (Kamczyc et al. 2018). Additionally, we have recorded rare mite species of mesostigmatid mites i.e. *V. mollis* which was reported for instance from the area of Bielinek at Oder Nature Reserve or from the soil environment in Góry Stołowe National Park (Skorupski and Gołojuch 1996 a, b; Skorupski and Łabędzki, 2004; Kamczyc and Gwiazdowicz 2009; Kamczyc and Skorupski, 2014). The presence of rare Mesostigmata species in that study may be caused by the food availability, mobility, as well as microhabitat conditions (Koehler 1997, 1999a, 1999b; Walter and Proctor 1999). We have also noticed *A. halleri*, an European species reported from forest and agricultural habitats (Bogdanowicz et al. 2008). Moreover, representatives of this species were recorded in decomposed organic material, in sandy and loamy soils. This species was also reported on insects from family Scarabaeidae and Carabidae (Skorupski et al. 2013) which may relate to its low abundance in our study in soils. We have also recorded *L. cuneoliger*, known from deciduous forest habitats (Bogdanowicz et al. 2008). It has also been reported from mosses and litter (Karg 1993). We have also recorded *T. pauperior*. Skorupski et al. (2013) and Bogdanowicz et al. (2008) stated that this species is widely distributed in Europe, where it inhabit the soil of mixed, deciduous and coniferous forests (Skorupski et al. 2013).

In conclusion, our study indicated that the soil environment in Kokorycz Nature Reserve creates favourable conditions for a diverse and abundant mite community. This also supports our assumption that KNR, as a protected area is characterized by a high ecological stability despite its small area.

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