Oribatid mites for monitoring Arctic ecosystems: comparing morphological analysis and COI metabarcoding along a disturbance gradient

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Supplementary materials

Table S1. Results of comparative analysis of the oribatid community indicators in the study sites with minimal (or no) negative impact: 9/22; 10/22; 11/22 in 2022 and 15/23; 16/23; 19/23 in 2023 near Nikel and Zapolyarny in northwestern Russia compiled based on data obtained by the morphological analysis (Kruskal–Wallis test).

Indicators	2022		2023	
	H	p	H	p
Species occurrence	0,72	0,69	4,1	0,11
Simpson index (1–D)	0,04	0,98	1,65	0,44
Shannon index (H)	0,15	0,93	1,89	0,39
Dominant species	2,62	0,23	1,08	0,56
"Other" species	0,35	0,84	2,8	0,24

Statistically significant associations are shown in bold.

Table S2. Taxonomic composition of oribatid mites across study sites near Nikel and Zapolyarny in northwestern Russia in 2022, compiled based on data obtained by morphological approach.

Species	6/22	6A/22	7/22	8A/22	9/22	10/22	11/22
Palaeacarus hystricinus Trägårdh, 1932	–	–	+	–	+	+	–
Palaeacarus kamenskii (Zachvatkin, 1948)	–	+	–	+	–	+	–
Brachychthonius sp.	–	–	–	+	–	–	–
Eobrachychthonius sp.	+	+	+	–	+	–	+
Liochthonius sp.	–	–	+	+	+	+	+
Eulohmannia ribagai (Berlese, 1910)	–	–	+	+	+	–	+
Trhypochthonius sp. 1	–	–	–	–	–	+	–
Trhypochthonius sp. 2	–	–	–	–	–	+	–
Malaconothrus sp.	–	–	–	–	–	–	+
Nothrus borussicus Sellnick, 1929	–	–	–	–	–	+	–
Camisia solhoeyi Colloff, 1993	–	–	–	–	+	–	–
Heminothrus (Heminothrus) longisetosus (Willmann, 1925)	–	–	–	–	–	–	+
Heminothrus (Platynothrus) humicola (Forsslund, 1955)	–	–	–	–	+	+	+
Nanhermannia sellnicki Forsslund, 1958	+	+	–	+	+	+	+
Porobelba spinosa (Sellnick, 1920)	–	+	+	+	+	+	+
Ceratoppia bipilis (Hermann, 1804)	–	–	–	–	–	–	+
Adoristes ovatus poppei (Oudemans, 1906)	–	–	–	–	–	+	+
Eueremaeus oblongus silvestris (Forsslund, 1956)	–	–	+	–	–	+	+
Autogneta (Autogneta) parva Forsslund, 1947	+	–	+	–	+	+	+
Autogneta (Conchogneta) traegardhi Forsslund, 1947	+	+	–	+	+	+	+
Banksinoma lanceolata (Michael, 1885)	–	+	–	–	–	–	–
Rhinoppia subpectinata (Oudemans, 1900)	–	+	+	+	+	+	+
Dissorhina ornata (Oudemans, 1900)	–	+	–	+	+	+	+
Lauroppia maritima acuminata (Strenzke, 1951)	–	–	–	+	–	–	+
Moritzoppia (Moritzoppia) unicarinata (Paoli, 1908)	–	+	+	–	+	–	+
Moritzoppia (Pentoppia) splendens (Koch, 1841)	–	–	–	–	–	–	+
Oppiella (Moritzoppiella) neerlandica (Oudemans, 1900)	–	+	+	–	+	+	+

Species	6/22	6A/22	7/22	8A/22	9/22	10/22	11/22
Oppiella (Oppiella) nova (Oudemans, 1902)	+	+	+	+	+	+	+
Quadroppia quadricarinata (Michael, 1885)	–	–	–	–	+	+	+
Suctobelbella sp. 1	–	+	+	+	+	+	+
Suctobelbella sp. 2	–	–	–	+	+	+	+
Suctobelbella sp. 3	–	–	–	–	+	+	+
Carabodes areolatus Berlese, 1916	–	–	–	–	–	+	+
Carabodes labyrinthicus (Michael, 1879)	+	–	–	–	+	+	–
Carabodes marginatus (Michael, 1884)	–	–	–	–	–	+	+
Tectocepheus velatus (Michael, 1880)	+	–	+	–	+	+	+
Eupelops sp.	+	+	–	–	+	–	–
Ceratozetella thienemanni (Willmann, 1943)	–	+	+	+	+	+	+
Ceratozetes sp.	–	–	–	–	+	–	+
Melanozetes mollicomus (Koch, 1839)	+	–	–	–	–	+	+
Trichoribates sp.	–	–	–	–	+	–	–
Chamobates pusillus (Berlese, 1895)	–	+	–	+	+	+	+
Diapterobates cf. *reticulatus* (Koch, 1879)	–	–	–	–	+	+	+
Mycobates parmeliae (Michael, 1884)	–	–	–	–	–	+	–
Punctoribates sp.	–	–	–	–	+	–	–
Oribatula tibialis (Nicolet, 1855)	+	+	–	–	–	+	–
Hemileius initialis (Berlese, 1908)	–	+	–	+	+	+	–
Scheloribates pallidulus latipes (Koch, 1844)	–	–	+	–	+	–	–
Pilogalumna tenuiclava (Berlese, 1908)	–	–	–	–	–	+	+
Total number of species				49			
Total number of genera				39			
Total number of families				27			

Table S3. Taxonomic composition of oribatid mites across study sites near Nikel and Zapolyarny in northwestern Russia in 2023, compiled based on data obtained by morphological approach.

Species	6B/23	13/23	7B/23	17/23	14/23	15/23	16/23	19/23
Palaeacarus hystricinus Trägårdh, 1932	–	–	–	+	+	–	–	–
Palaeacarus kamenskii (Zachvatkin, 1948)	–	–	–	+	–	+	–	–
Brachychthonius sp.	–	–	–	–	+	–	+	–
Eobrachychthonius sp.	–	–	–	–	–	–	–	+
Liochthonius sp.	–	–	+	–	+	+	+	+
Sellnickochthonius sp.	–	–	+	–	–	+	+	–
Hypochthonius rufulus Koch, 1835	–	–	–	–	+	–	–	–
Eulohmannia ribagai (Berlese, 1910)	+	–	+	+	–	+	+	+
Camisia (Camisia) spinifer (Koch, 1835)	–	–	–	–	–	–	+	–
Camisia (Ensicamisia) solhoeyi Colloff, 1993	–	–	–	–	+	–	–	–
Heminothrus (Heminothrus) longisetosus (Willmann, 1925)	–	–	–	–	–	–	+	–
Heminothrus (Platynothrus) humicola (Forsslund, 1955)	–	–	–	–	+	+	+	+
Heminothrus (Platynothrus) peltifer (Koch, 1839)	–	–	–	–	–	–	+	–
Nanhermannia sellnicki Forsslund, 1958	+	–	–	–	+	+	+	+
Porobelba spinosa (Sellnick, 1920)	–	–	+	–	–	+	+	+
Adoristes ovatus poppei (Oudemans, 1906)	–	–	–	–	–	+	+	–
Birsteinius sp.	–	–	–	–	+	–	–	–
Eueremaeus oblongus silvestris (Forsslund, 1956)	–	–	–	–	+	+	+	–
Autogneta (Autogneta) parva Forsslund, 1947	–	–	–	+	+	–	+	+
Autogneta (Conchogneta) traegardhi Forsslund, 1947	–	–	+	+	+	+	+	+

Species	6B/23	13/23	7B/23	17/23	14/23	15/23	16/23	19/23
Microppia minus (Paoli, 1908)	–	–	–	+	–	+	–	+
Rhinoppia subpectinata (Oudemans, 1900)	–	+	+	+	+	+	+	+
Dissorhina ornata (Oudemans, 1900)	–	–	+	–	+	+	+	+
Lauroppia maritima acuminata (Strenzke, 1951)	–	–	+	–	+	+	+	–
Moritzoppia (Moritzoppia) unicarinata (Paoli, 1908)	–	–	–	–	+	–	–	–
Moritzoppia (Pentoppia) splendens (Koch, 1841)	–	–	–	–	+	–	–	–
Moritzoppia sp.	–	–	–	+	–	–	+	+
Oppiella (*Moritzoppiella) neerlandica* (Oudemans, 1900)	–	–	–	+	+	+	+	+
*Oppiella (Oppiella) nov*a (Oudemans, 1902)	+	+	+	+	+	+	+	+
Quadroppia quadricarinata (Michael, 1885)	–	–	–	–	+	+	+	+
Suctobelbella sp. 1	–	–	+	+	+	+	+	+
Suctobelbella sp. 2	–	–	–	+	+	+	+	+
Suctobelbella sp. 3	–	–	–	–	+	+	+	+
Carabodes areolatus Berlese, 1916	–	–	–	–	–	+	+	+
Carabodes labyrinthicus (Michael, 1879)	–	–	–	–	–	+	+	–
Carabodes marginatus (Michael, 1884)	–	–	–	–	–	–	+	–
Tectocepheus velatus (Michael, 1880)	–	–	+	–	+	+	+	+
Eupelops sp.	–	–	–	–	+	–	–	–
Ceratozetella thienemanni (Willmann, 1943)	–	–	+	+	+	+	+	+
Melanozetes mollicomus (Koch, 1839)	–	–	–	–	–	–	+	–
Chamobates pusillus (Berlese, 1895)	–	–	–	+	+	+	+	+
Diapterobates cf. *reticulatus* (Koch, 1879)	–	–	–	–	+	–	+	–
Oribatula tibialis (Nicolet, 1855)	–	–	+	+	+	+	+	+
Hemileius initialis (Berlese, 1908)	–	–	–	+	+	+	+	+
Liebstadia similis (Michael, 1888)	–	–	–	–	+	–	–	–
Scheloribates pallidulus latipes (Koch, 1844)	–	–	+	–	–	+	–	–
Indoribates (Haplozetes) vindobonensis (Willmann, 1935)	–	–	–	–	–	–	–	+
Neoribates sp.	–	–	–	–	–	–	+	–
Total number of species					48			
Total number of genera					36			
Total number of families					25			

Table S4. Taxonomic composition of oribatid mites across study sites near Nikel and Zapolyarny in northwestern Russia in 2022, compiled based on data obtained by DNA metabarcoding.

OTU	6/22	6A/22	7/22	8A/22	9/22	10/22	11/22
OTU 18 (*Porobelba spinosa*)	+	+	+	+	+	+	+
OTU 392 (unc Brachychthoniidae)	+	+	+	+	+	+	+
OTU 428 (*Dissorhina ornata*)	+	+	+	+	+	+	+
OTU 10 (unc *Tectocepheus*)	+	+	+	+	+	+	+
OTU 232 (*Chamobates borealis*)	+	+	+	+	+	+	+
OTU 236 (*Oppiella nova*)	+	+	+	+	+	+	+
OTU 125 (unc *Tectocepheus*)	+	+	+	+	+	+	+
OTU 42 (unc *Nanhermannia*)	+	+	–	–	+	+	+
OTU 153 (unc Brachychthoniidae)	–	+	+	–	+	–	+
OTU 2373 (unc Brachychthoniidae)	+	–	–	+	–	–	–
OTU 175 (*Nothrus pratensis*)	–	+	–	–	+	+	+
OTU 70 (*Hemileius initialis*)	+	+	+	+	+	+	+
OTU 319 (*Oppiella nova*)	+	+	+	+	+	+	+
OTU 138 (unc *Tectocepheus*)	–	+	–	+	+	+	+

OTU	6/22	6A/22	7/22	8A/22	9/22	10/22	11/22
OTU 825 (*Porobelba spinosa*)	–	–	+	–	–	+	–
OTU 227 (*Tectocepheus velatus)*	+	+	+	+	+	+	+
OTU 869 (*Chamobates borealis*)	–	+	–	–	+	+	+
OTU 674 (unc *Neonothrus*)	–	+	+	+	+	+	+
OTU 208 (*Porobelba spinosa*)	+	+	+	+	+	+	+
OTU 627 (*Microppia minus*)	–	–	+	+	–	–	–
OTU 320 (*Tectocepheus velatus*)	+	–	+	+	–	+	+
OTU 459 (*Palaeacarus kamenskii*)	–	+	+	–	+	–	+
OTU 87 (*Liochthonius muscorum*)	+	+	+	+	+	+	–
OTU 251 (*Adoristes ovatus*)	–	+	–	+	–	+	+
OTU 864 (*Oppiella nova*)	–	–	+	+	–	+	–
OTU 589 (*Suctobelbella subtrigona*)	–	–	+	+	+	+	+
OTU 3388 (*Carabodes ornatus*)	+	–	+	–	–	+	+
OTU 28 (*Platynothrus peltifer*)	+	+	–	+	+	–	+
OTU 476 (*Hemileius initialis*)	+	+	+	+	+	+	+
OTU 182 (*Chamobates borealis*)	+	+	+	+	+	+	+
OTU 671 (*Hemileius initialis*)	+	+	+	–	+	+	+
OTU 590 (*Eupelops torulosus*)	–	+	–	–	–	–	–
OTU 26 (unc *Tectocepheus*)	+	–	+	+	–	+	–
OTU 207 (unc *Oppiella*)	+	–	+	+	–	+	–
OTU 1074 (*Oppiella nova*)	–	+	+	–	+	–	+
OTU 2576 (unc Suctobelbidae)	–	+	–	–	–	–	–
OTU 171 (*Oribatula tibialis*)	–	+	–	–	+	–	+
OTU 519 (*Autogneta longilamellata*)	–	–	+	+	–	+	+
OTU 1370 (unc *Oppiella*)	–	–	–	–	–	+	–
OTU 752 (unc Suctobelbidae)	–	+	+	–	–	–	+
OTU 1534 (*Diapterobates humeralis*)	–	–	–	+	+	–	–
OTU 1250 (*Oribatula tibialis*)	+	+	+	+	–	–	+
OTU 935 (*Oribatula tibialis*)	–	+	–	+	–	+	+
OTU 222 (unc *Oribatula*)	–	+	–	–	+	–	+
OTU 264 (*Carabodes ornatus*)	+	–	+	+	+	+	+
OTU 1990 (unc *Eobrachychthonius*)	+	+	+	+	–	–	+
OTU 2146 (*Oppiella nova*)	+	–	–	–	–	–	–
OTU 832 (*Carabodes labyrinthicus*)	–	–	–	–	–	+	+
OTU 1186 (unc *Tectocepheus*)	–	–	–	–	–	+	+
OTU 624 (unc Suctobelbidae)	–	–	–	–	+	+	+
OTU 732 (unc Tectocepheus)	–	–	–	–	+	+	+
OTU 1350 (unc *Tectocepheus*)	–	–	+	–	–	+	–
OTU 2752 (unc *Tectocepheus*)	–	–	+	–	–	–	–
OTU 1136 (unc Suctobelbidae)	–	–	+	–	–	–	–
OTU 412 (unc *Tectocepheus*)	–	+	–	–	+	+	+
OTU 296 (unc *Tectocepheus*)	+	–	–	+	–	+	–
OTU 364 (*Eremaeus insertus*)	–	+	–	–	+	–	+
OTU 1128 (unc *Oppiella*)	–	–	–	+	–	–	–
OTU 568 (unc *Tectocepheus*)	+	–	+	+	–	+	+
OTU 1114 (*Adoristes ovatus*)	–	–	–	–	–	+	+
OTU 323 (*Platynothrus peltifer*)	+	+	–	+	+	+	–
OTU 2095 (*Ceratozetella thienemanni*)	–	–	–	+	+	–	+
OTU 259 (*Belba compta*)	–	+	–	–	–	–	+
OTU 294 (*Conchogneta traegardhi*)	–	+	–	+	–	+	+

OTU	6/22	6A/22	7/22	8A/22	9/22	10/22	11/22
OTU 1328 (*Oppiella uliginosa*)	–	+	–	–	+	–	–
OTU 3401 (unc *Eupelops*)	+	–	–	–	–	–	–
OTU 422 (*Quadroppia quadricarinata*)	+	+	–	+	+	+	+
OTU 1232 (unc *Tectocepheus*)	–	–	–	+	+	+	+
OTU 306 (unc *Tectocepheus*)	+	–	–	+	+	+	+
OTU 370 (unc Ceratozetidae)	–	+	–	–	+	–	+
OTU 1000 (*Oribatula tibialis*)	–	+	–	–	+	–	–
OTU 165 (unc Brachychthoniidae)	–	+	–	–	+	–	–
OTU 2413 (*Diapterobates notatus*)	–	–	+	+	+	+	–
OTU 2206 (*Diapterobates humeralis*)	–	–	–	–	+	–	–
OTU 309 (unc *Tectocepheus*)	+	–	–	+	–	+	–
OTU 566 (unc Suctobelbidae)	+	+	–	+	–	+	–
OTU 180 (unc Brachychthoniidae)	+	+	–	–	+	–	–
OTU 1345 (unc Suctobelbidae)	–	–	–	–	–	+	+
OTU 2015 (*Oppiella uliginosa*)	–	–	–	+	–	–	+
OTU 1149 (unc *Heminothrus*)	–	+	–	–	–	–	+
OTU 4108 (unc *Suctobelbella*)	–	+	–	–	+	+	+
OTU 4041 (unc Brachychthoniidae)	+	+	–	–	+	–	+
OTU 645 (*Oppiella nova*)	–	–	+	+	+	–	+
OTU 484 (unc *Tectocepheus*)	–	+	–	–	+	–	–
OTU 2872 (*Oppiella nova*)	–	–	+	+	–	–	–
OTU 1514 (*Carabodes subarcticus*)	–	–	–	–	–	+	+
OTU 1489 (unc Oppiidae)	–	–	–	+	+	–	–
OTU 425 (unc *Suctobelbella*)	–	+	–	–	–	–	+
OTU 786 (*Oppiella nova*)	–	+	–	–	+	–	+
OTU 492 (*Oribatella sexdentata*)	–	–	–	+	–	+	–
OTU 315 (*Tyrphonothrus maior*)	–	–	–	+	–	+	–
OTU 231 (*Malaconothrus mollisetosus*)	–	–	–	–	–	+	+
OTU 257 (*Liochthonius muscorum*)	+	–	+	–	–	–	–
OTU 851 (unc *Tectocepheus*)	+	–	–	–	–	–	–
OTU 2744 (*Berniniella hauseri*)	–	–	–	–	–	–	+
OTU 1909 (unc Oppiidae)	–	–	–	–	–	+	–
OTU 896 (*Peloribates canadensis*)	–	–	–	+	–	+	–
OTU 676 (unc Malaconothridae)	+	–	–	+	–	–	–
OTU 1310 (*Quadroppia quadricarinata*)	–	–	–	–	–	–	+
OTU 3768 (unc *Suctobelbella*)	+	–	–	–	–	–	–
OTU 2966 (unc Oppiidae)	–	–	–	–	+	–	+
OTU 906 (unc *Liebstadia*)	–	–	–	+	–	+	–
OTU 2006 (*Oribatula tibialis*)	–	–	–	+	–	+	–
OTU 2347 (unc Sarcoptiformes)	–	–	–	+	–	–	–
OTU 2359 (*Suctobelbella subcornigera*)	–	–	–	–	–	–	+
OTU 500 (unc *Suctobelbella*)	–	–	–	–	–	–	+
OTU 213 (*Eobrachychthonius latior*)	–	–	–	+	–	–	–
OTU 1207 (unc *Tectocepheus*)	–	–	–	–	+	–	+
OTU 776 (*Ceratozetes parvulus*)	–	–	–	–	–	–	+
OTU 545 (unc Brachychthoniidae)	–	+	–	–	–	–	–
OTU 2498 (unc Oppiidae)	+	–	–	–	–	–	–
OTU 410 (unc *Eupelops*)	+	–	–	–	–	–	+
OTU 3190 (unc *Liebstadia*)	–	–	–	–	–	+	–
OTU 2900 (unc Suctobelbidae)	–	–	–	+	–	+	–

OTU	6/22	6A/22	7/22	8A/22	9/22	10/22	11/22
OTU 1721 (*Eueremaeus silvestris*)	–	–	–	–	–	–	+
OTU 4133 (*Heminothrus longisetosus*)	–	–	–	–	–	–	+
OTU 94 (unc Brachychthoniidae)	–	–	–	–	–	–	+
OTU 2717 (unc *Nothrus*)	–	–	–	–	–	–	+
OTU 998 (unc Suctobelbidae)	+	–	–	–	–	+	–
OTU 256 (unc Brachychthoniidae)	–	+	–	–	–	–	–
OTU 4186 (*Platynothrus peltifer*)	–	–	–	–	–	–	+
OTU 1234 (unc *Tectocepheus*)	+	–	–	–	–	–	–
OTU 763 (*Platynothrus punctatus*)	–	–	–	–	–	–	+
OTU 2952 (unc *Eremaeus*)	–	–	–	–	–	–	+
OTU 2552 (*Carabodes labyrinthicus*)	–	–	–	–	–	–	+
OTU 1189 (unc *Tectocepheus*)	–	–	–	–	–	+	–
OTU 237 (*Oppiella nova*)	–	–	–	–	–	+	–
OTU 866 (unc *Tectocepheus*)	–	–	–	+	–	–	–
Total number of OUTs				128			
Total number of genera				39			
Total number of families				26			

Table S5. Taxonomic composition of oribatid mites across study sites near Nikel and Zapolyarny in northwestern Russia in 2023, compiled based on data obtained by DNA metabarcoding.

OTU	6B/23	13/23	7B/23	17/23	14/23	15/23	16/23	19/23
OTU 154 (*Porobelba spinosa*)	+	–	+	+	+	+	+	+
OTU 82 (unc Brachychthoniidae)	+	+	+	+	–	–	–	+
OTU 6 (*Tyrophagus putrescen*tiae)	+	+	+	+	+	+	+	+
OTU 206 (*Liochthonius muscorum*)	+	+	–	–	+	+	+	–
OTU 302 (unc *Tyrophagus*)	+	+	–	–	–	–	–	–
OTU 192 (*Tectocepheus velatus*)	+	–	+	+	+	+	+	+
OTU 270 (*Hemileius initialis*)	+	–	–	–	+	+	+	–
OTU 223 (unc *Tectocepheus*)	+	–	–	+	–	+	+	+
OTU 560 (unc *Tectocepheus*)	+	+	+	+	–	–	–	+
OTU 659 (*Suctobelbella subtrigona*)	+	+	–	–	+	–	+	+
OTU 224 (unc *Tectocepheus*)	–	–	+	+	–	–	–	+
OTU 399 (unc *Tectocepheus*)	–	–	+	+	–	–	+	+
OTU 492 (*Oppiella nova*)	–	–	+	+	+	+	+	+
OTU 466 (*Chamobates borealis*)	+	+	+	+	+	+	+	+
OTU 260 (*Ceratozetella thienemanni*)	–	+	+	+	–	+	+	+
OTU 810 (*Hemileius initialis*)	–	+	+	–	+	+	+	+
OTU 1566 (unc *Oppiella*)	–	–	+	+	+	–	–	–
OTU 723 (*Oppiella nova*)	–	–	+	+	–	–	+	–
OTU 883 (*Oribatula tibialis*)	+	–	–	+	+	–	+	+
OTU 180 (unc Nanhermanniidae)	–	+	+	+	+	+	+	+
OTU 335 (*Dissorhina ornata*)	+	+	+	–	+	+	+	+
OTU 485 (*Oribatula tibialis*)	–	–	–	–	+	+	+	+
OTU 181 (*Oppiella nova*)	+	+	+	+	+	+	+	+
OTU 388 (*Oppiella uliginosa*)	+	–	–	–	+	–	+	+
OTU 55 (unc *Tectocepheus*)	–	–	–	–	+	+	+	–
OTU 421 (*Platynothrus peltifer*)	–	–	–	–	+	–	+	+
OTU 299 (*Hemileius initialis*)	+	–	–	–	+	+	+	+
OTU 3043 (unc *Tectocepheus*)	–	–	–	+	+	+	–	+

OTU	6B/23	13/23	7B/23	17/23	14/23	15/23	16/23	19/23
OTU 103 (*Carabodes ornatus*)	+	+	+	+	+	–	+	+
OTU 672 (*Oppiella uliginosa*)	–	–	–	+	+	–	+	+
OTU 3831 (*Hemileius initialis*)	–	–	–	–	+	+	–	–
OTU 587 (unc Suctobelbidae)	–	+	–	–	+	–	+	+
OTU 2330 (*Hemileius initialis*)	–	–	–	–	+	+	+	+
OTU 337 (*Palaeacarus kamenskii*)	+	–	–	–	+	–	–	+
OTU 419 (*Liochthonius muscorum*)	–	–	+	–	+	–	+	–
OTU 255 (unc *Tectocepheus*)	–	–	–	–	–	–	+	+
OTU 614 (unc *Protoribotritia*)	+	–	+	–	–	–	+	–
OTU 4105 (unc Brachychthoniidae)	–	–	–	+	+	–	–	–
OTU 988 (*Oppiella nova*)	–	–	–	–	–	–	–	+
OTU 1333 (*Quadroppia quadricarinata*)	–	–	–	+	+	–	–	–
OTU 290 (unc Suctobelbidae)	–	–	–	+	+	–	–	+
OTU 2313 (unc Oppiidae)	–	–	–	+	–	–	–	–
OTU 2698 (*Moritzoppia keilbachi*)	–	–	+	–	–	–	–	–
OTU 273 (*Quadroppia quadricarinata*)	–	–	–	–	–	+	+	–
OTU 832 (unc *Tectocepheus*)	–	–	–	–	+	–	+	+
OTU 477 (*Liochthonius muscorum*)	–	–	–	+	–	–	+	+
OTU 597 (*Quadroppia quadricarinata*)	–	–	+	+	–	–	–	–
OTU 919 (*Oppiella nova*)	–	–	–	+	–	–	+	+
OTU 1972 (*Oribatula tibialis*)	–	–	–	–	+	–	+	–
OTU 493 (*Fosseremus laciniatus*)	–	–	–	+	–	–	+	+
OTU 210 (*Oppiella nova*)	–	–	+	+	–	–	–	–
OTU 2682 (unc *Tectocepheus*)	–	–	–	–	–	+	+	+
OTU 809 (unc Brachychthoniidae)	–	–	+	+	+	–	–	–
OTU 182 (*Galumna dimorpha*)	–	–	–	–	+	–	+	–
OTU 3119 (*Oppiella nova*)	–	–	–	–	–	–	–	+
OTU 1092 (*Oppiella nova*)	–	+	–	+	–	–	+	+
OTU 3631 (*Dissorhina ornata*)	–	–	–	–	–	–	+	–
OTU 722 (unc Oppiidae)	–	–	–	–	+	–	–	+
OTU 891 (unc *Suctobelbella*)	–	–	–	–	–	–	–	+
OTU 609 (*Porobelba spinosa*)	+	+	–	–	+	+	+	–
OTU 3861 (*Chamobates borealis*)	+	+	–	–	+	–	+	–
OTU 922 (*Belba compta*)	–	–	–	–	+	–	–	–
OTU 3489 (*Oppiella nova*)	–	–	–	+	–	–	–	+
OTU 1560 (*Oppiella nova*)	–	–	+	+	–	–	–	–
OTU 3465 (*Chamobates borealis*)	–	–	–	–	+	–	+	–
OTU 757 (unc Oribatulidae)	–	–	+	–	–	–	–	+
OTU 386 (unc Sarcoptiformes)	+	+	–	–	+	–	+	–
OTU 1725 (*Dissorhina ornata*)	–	–	+	–	–	–	–	+
OTU 439 (unc *Tectocepheus*)	–	–	+	–	+	+	+	+
OTU 487 (unc *Tectocepheus*)	–	–	–	+	–	–	–	+
OTU 3676 (unc Oppiidae)	–	–	–	+	–	–	–	–
OTU 2157 (unc Suctobelbidae)	–	–	–	–	–	–	+	–
OTU 3639 (*Quadroppia quadricarinata*)	–	–	–	–	+	–	–	–
OTU 370 (*Chamobates borealis*)	–	–	–	–	+	+	+	–
OTU 1009 (unc *Tectocepheus*)	–	–	–	+	–	–	–	+
OTU 581 (unc *Tectocepheus*)	–	–	–	–	+	–	+	+
OTU 1549 (*Diapterobates humeralis*)	–	–	–	+	–	–	–	–
OTU 446 (*Oppiella nova*)	–	–	–	–	+	–	+	–

OTU	6B/23	13/23	7B/23	17/23	14/23	15/23	16/23	19/23
OTU 358 (*Oppiella nova*)	–	–	–	–	+	–	+	–
OTU 1581 (unc Brachychthoniidae)	–	–	–	–	+	–	–	–
OTU 2372 (unc *Eremaeus*)	–	–	–	–	+	–	–	+
OTU 728 (*Punctoribates hexagonus*)	–	–	+	–	–	–	–	–
OTU 829 (unc *Oppiella*)	–	–	–	+	–	–	–	–
OTU 1079 (*Platynothrus peltifer*)	–	–	–	–	+	+	+	–
OTU 604 (*Nothrus borussicus*)	–	–	–	–	+	–	+	–
OTU 2065 (unc *Suctobelbella*)	–	–	–	–	+	–	+	+
OTU 1149 (unc *Suctobelbella*)	–	–	–	–	–	–	–	+
OTU 2081 (*Adoristes ovatus*)	–	–	–	–	–	+	+	–
OTU 1288 (*Carabodes subarcticus*)	–	–	–	–	+	–	+	–
OTU 927 (unc *Tectocepheus*)	–	–	–	–	+	+	+	+
OTU 3472 (*Dissorhina* ornata)	–	–	–	–	–	–	–	+
OTU 1133 (*Nothrus pratensis*)	–	–	+	–	–	–	–	–
OTU 1858 (unc Oppiidae)	–	–	–	–	–	–	–	+
OTU 1453 (unc *Tectocepheus*)	–	–	–	–	+	–	+	–
OTU 1408 (unc *Tectocepheus*)	–	–	+	–	–	–	–	–
OTU 845 (unc *Suctobelbidae*)	–	–	+	–	–	–	–	–
OTU 642 (unc Brachychthoniidae)	–	–	–	–	–	–	+	+
OTU 1420 (*Nothrus anauniensis*)	–	–	–	–	–	–	+	+
OTU 2522 (unc Damaeidae)	–	–	–	–	–	–	+	–
OTU 1935 (*Oppiella nova*)	–	–	–	–	+	–	+	+
OTU 2039 (unc *Tectocepheus*)	–	–	–	–	–	+	+	+
OTU 2158 (*Carabodes labyrinthicus*)	–	–	–	–	+	–	+	–
OTU 850 (*Quadroppia quadricarinata*)	–	–	–	–	+	–	–	+
OTU 687 (*Quadroppia quadricarinata*)	–	–	–	–	+	–	+	–
OTU 843 (unc Oppiidae)	–	–	–	–	+	–	+	–
OTU 2456 (unc Suctobelbidae)	–	–	+	–	–	–	–	–
OTU 3859 (unc Brachychthoniidae)	–	–	–	+	–	–	–	–
OTU 953 (*Fosseremus laciniatus*)	–	–	–	–	+	–	–	–
OTU 3655 (unc *Tectocepheus*)	–	–	–	–	+	–	+	–
OTU 2109 (unc Suctobelbidae)	–	–	–	–	+	–	+	–
OTU 2707 (unc *Suctobelbella*)	–	–	+	–	–	–	–	–
OTU 1041 (*Nothrus borussicus*)	–	–	–	–	+	–	+	–
OTU 3733 (unc *Tectocepheus*)	–	–	–	–	–	–	+	–
OTU 3847 (*Oppiella nova*)	–	–	–	–	+	–	+	–
OTU 1265 (*Tectocepheus sarekensis*)	–	–	–	–	+	–	–	–
OTU 901 (unc *Tectocepheus*)	–	–	–	–	+	–	+	–
OTU 1203 (*Quadroppia quadricarinata*)	–	–	–	–	+	–	+	–
OTU 2523 (unc Achipteriidae)	–	–	–	–	+	–	–	–
OTU 1878 (unc *Peloptulus*)	–	–	–	–	–	+	–	–
OTU 3334 (*Oppiella nova*)	–	–	–	–	+	–	–	–
OTU 2276 (*Ameronothrus lineatus*)	–	–	–	–	–	+	–	–
OTU 1714 (*Nothrus borussicus*)	–	–	–	–	–	–	–	–
OTU 2155 unc Oppiidae)	–	–	–	–	–	–	+	–
OTU 3144 (*Oppiella nova*)	–	–	–	–	–	–	+	–
OTU 867 (unc Suctobelbidae)	–	–	–	–	–	–	+	–
OTU 552 (unc *Suctobelbella*)	–	–	–	–	–	–	+	–
OTU 1743 (*Rhinoppia subpectinata*)	–	–	–	–	–	–	+	–
Total number of OUTs	127							

OTU	6B/23	13/23	7B/23	17/23	14/23	15/23	16/23	19/23
Total number of genera	34							
Total number of families	24							

Table S6. Spearman's rank correlations, with the Benjamini–Hochberg procedure used to control the FDR, between oribatid community indicators and the distance to the nearest industrial facility across study sites in 2022, 2023, and the pooled dataset.

Indicator	2022 (n = 7)			2023 (n = 8)			2022-2023 (n = 15)		
	r_s	p	p_{adj}	r_s	p	p_{adj}	r_s	p	p_{adj}
Morphological analysis									
Species richness	0.87	**0.016**	**0.038**	0.81	**0.019**	**0.021**	0.84	**<0.001**	**<0.001**
Species occurrence	0.87	**0.016**	**0.038**	0.83	**0.013**	**0.026**	0.86	**<0.001**	**<0.001**
Simpson index (1–D)	0.82	**0.032**	0.056	0.79	**0.024**	**0.025**	0.78	**0.001**	**0.001**
Shannon index (H)	0.77	**0.053**	0.062	0.81	**0.019**	**0.021**	0.78	**0.001**	**0.001**
Eudominant species	-0.84	**0.039**	0.055	-0.87	**0.014**	**0.023**	-0.84	**<0.001**	**<0.001**
Dominant species	0.45	0.326	0.326	0.89	**0.005**	**0.021**	0.76	**0.001**	**0.002**
"Other" species	0.94	**0.005**	**0.017**	0.83	**0.015**	**0.020**	0.87	**<0.001**	**<0.001**
Population density	0.95	**0.003**	**0.022**	0.90	**0.003**	**0.027**	0.89	**<0.001**	**<0.001**
Relative abundance	0.95	**0.003**	**0.022**	0.88	**0.007**	**0.019**	0.92	**<0.001**	**<0.001**
DNA metabarcoding									
OTU richness	0.65	0.129	0.129	0.78	**0.029**	0.059	0.63	**0.012**	**0.031**
OTU occurrence	0.78	**0.048**	0.085	0.85	**0.011**	**0.045**	0.66	**0.007**	**0.027**
Simpson index (1–D)	0.92	**0.005**	**0.039**	0.73	**0.048**	0.063	0.66	**0.007**	**0.027**
Shannon index (H)	0.90	**0.009**	**0.022**	0.74	**0.041**	0.066	0.78	**0.001**	**0.003**
Eudominant OTUs	-0.78	**0.051**	0.071	-0.90	**0.007**	0.057	-0.86	**<0.001**	**<0.001**
Dominant OTUs	0.93	**0.006**	**0.021**	0.52	0.195	0.222	0.78	**0.001**	**0.004**
"Other" OTUs	0.68	0.098	0.115	0.83	**0.016**	**0.042**	0.63	**0.011**	**0.034**

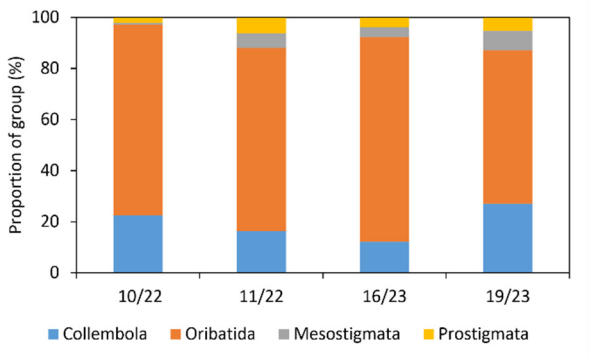


Figure S1. Relative abundance of different microarthropod groups (%) in samples collected at undisturbed sites near Nikel and Zapolyarny in northwestern Russia in 2022–2023.

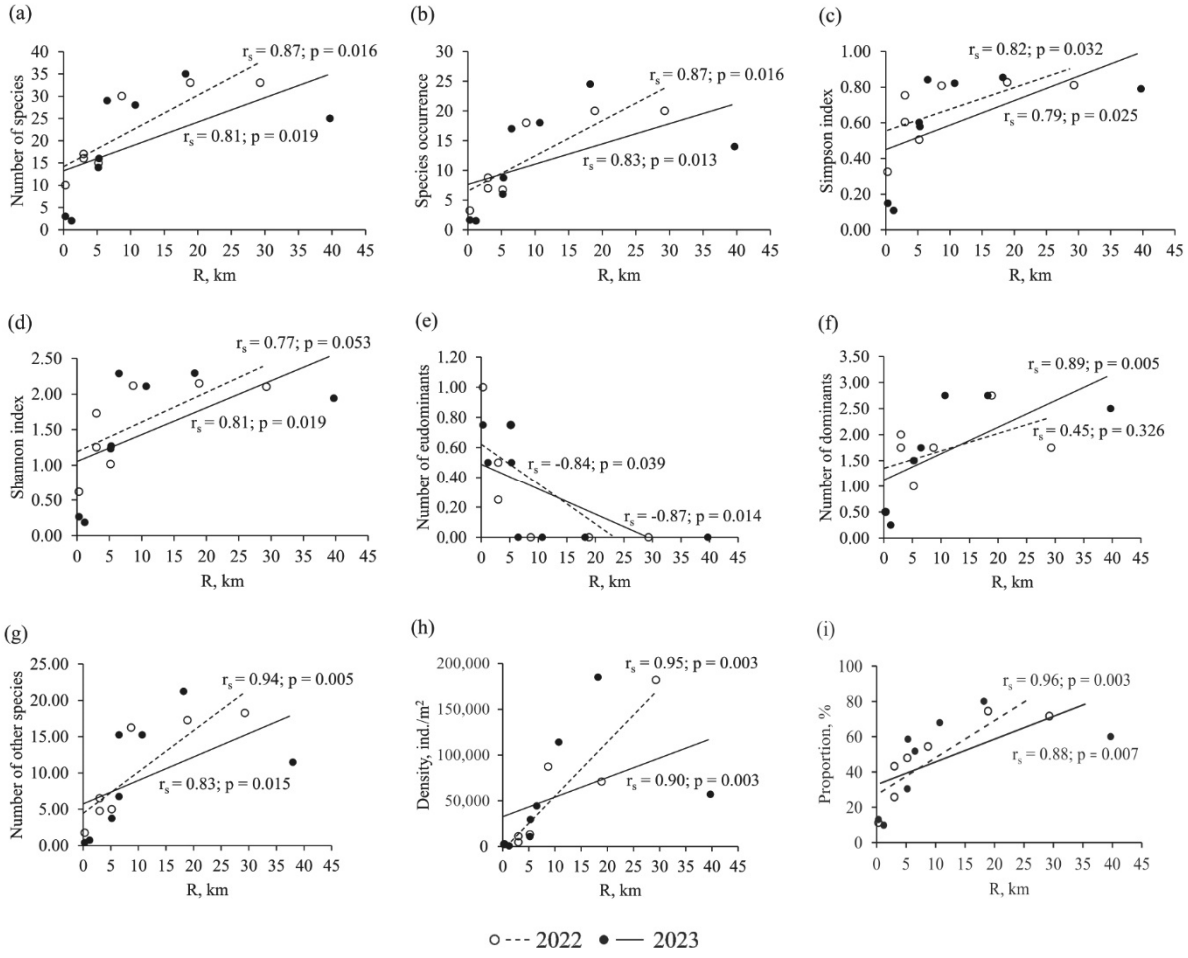


Figure S2. Spearman's rank correlation coefficients (r_s) between Oribatida indicators and the distance to the nearest industrial facility (R), calculated based on data obtained using the morphological approach. (**a**) Species richness. (**b**) Species occurrence. (**c**) Simpson index (1–D). (**d**) Shannon index (H). (**e**) Eudominant species. (**f**) Dominant species. (**g**) "Other" species. (**h**) Population density (ind./m²). (**i**) Relative abundance (%).

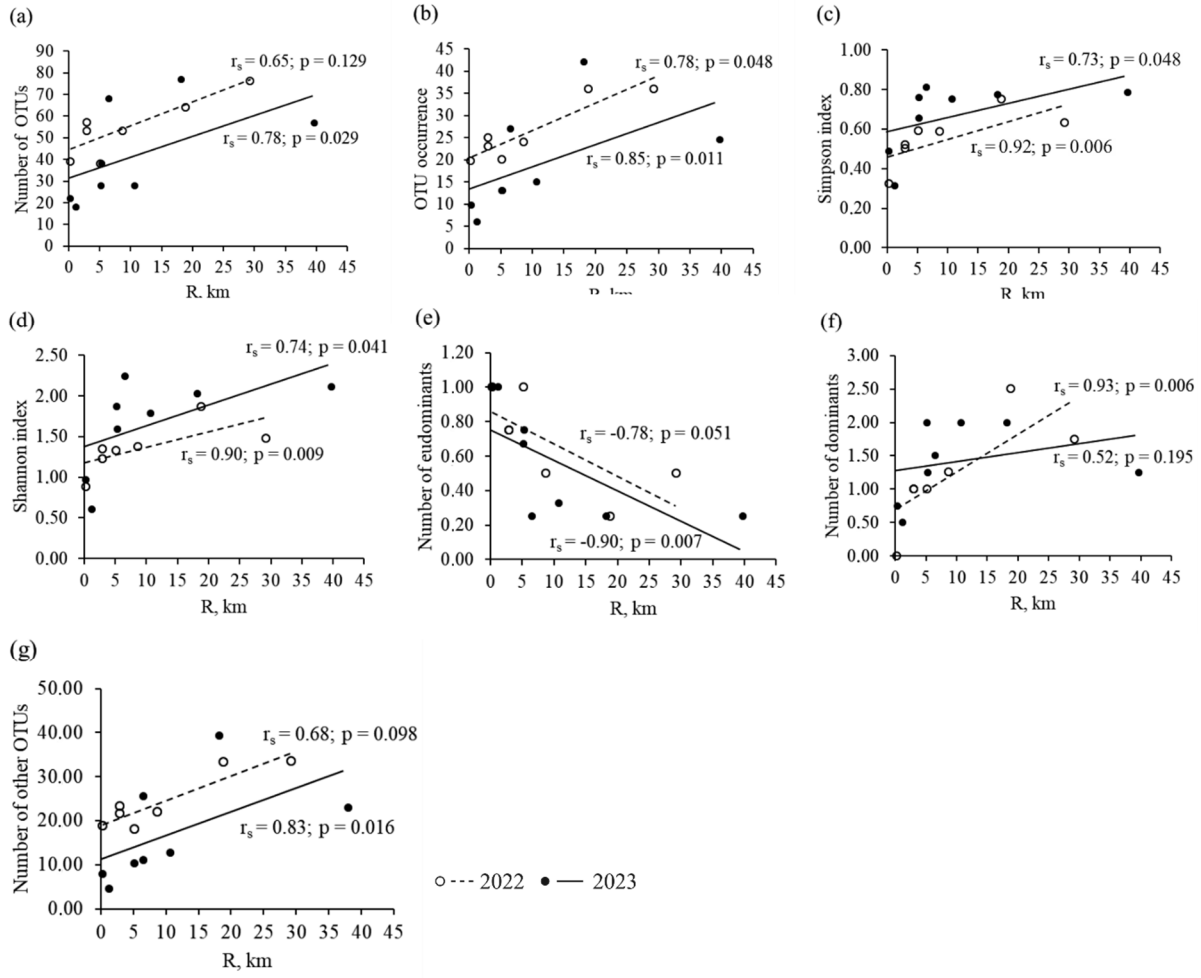


Figure S3. Spearman's rank correlation coefficients (r_s) between Oribatida indicators and the distance to the nearest industrial facility (R), calculated based on data obtained using DNA metabarcoding. (**a**) OTU richness. (**b**) OTU occurrence. (**c**) Simpson index (1–D). (**d**) Shannon index (H). (**e**) Eudominant OTUs. (**f**) Dominant OTUs. (**g**) "Other" OTUs.

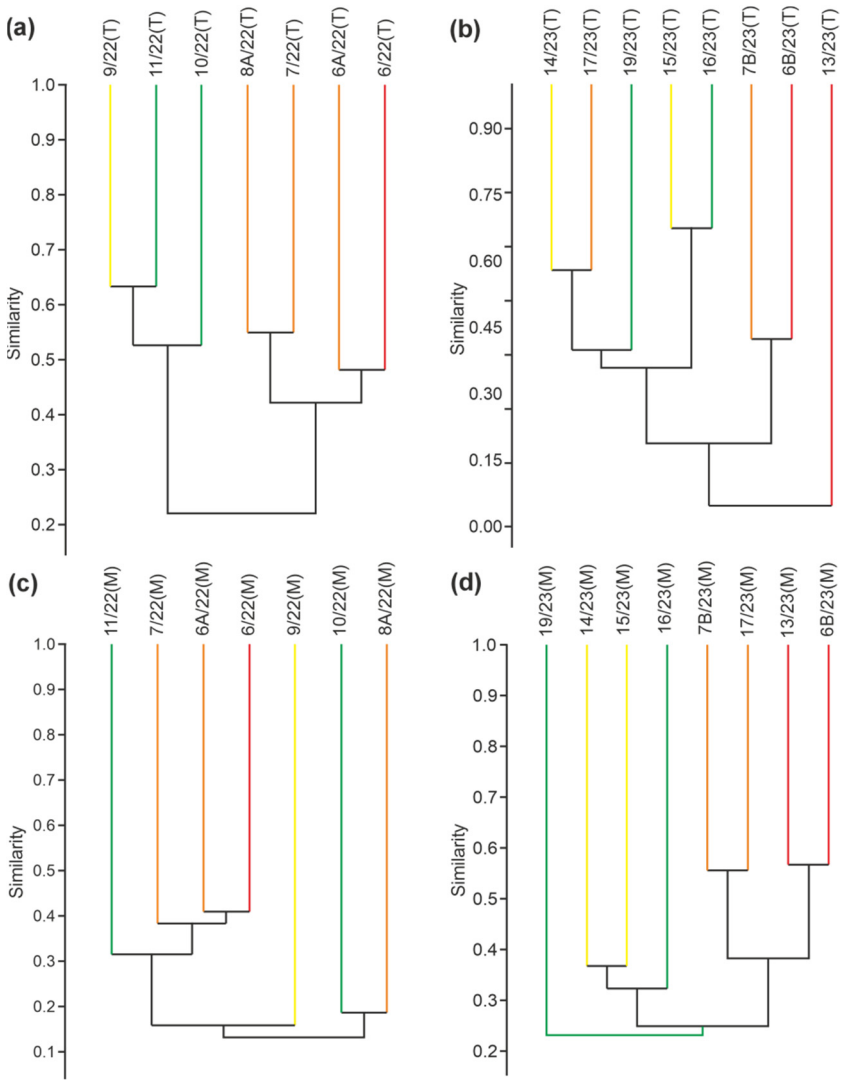


Figure S4. UPGMA clustering of oribatid mite communities based on Bray–Curtis similarity using morphological data (T; **a,b**) and metabarcoding data (M; **c,d**) from 2022 (**a,c**) and 2023 (**b,d**). Colors indicate disturbance categories: red – high; orange – medium; yellow – low; green – reference.