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THE COMMUNITIES OF THE ORIBATID MITES (*ACARI*: *ORIBATIDA*) OF THE ZAKOPANE ENVIRONS

ZESPOŁY MECHOWCÓW (*ACARI*: *ORIBATIDA*) OKOLIC ZAKOPANEGO

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Abstract: The structure of the oribatid mite (*Acarina*. *Oribatei*) communities in the environs of Zakopane and the Tatra National Park (TNP) was surveyed. Over 50 species of this group were found during the study held in September 1995. Among them about 30 were noted in this area for the first time. Similarity of the soil microarthropodes fauna of this region and the adjacent territories was analysed. Also the structure of the oribatid mite communities in different biotopes was analysed. An analysis of the impact of tourism on the oribatid mite communities was made drawing on the example of ski trails within the TNP and the surrounding area.

Key words: *Oribatida*, ski trails, human impact, Tatra National Park, Zakopane, southern Poland.

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Tresc: Zbadano strukturę zespołów mechowców (*Acarina*, *Oribatei*) w okolicach Zakopanego i w Tatrzańskim Parku Narodowym. Podczas badań przeprowadzonych we wrześniu 1995 zidentyfikowano ponad 50 gatunków należących do tej grupy. Spośród nich 30 stwierdzono tutaj po raz pierwszy. Zbadano podobieństwo glebowej fauny mikrostawonogów tego regionu i terenów przyległych. Przeanalizowano również strukturę zespołów mechowców w różnych biotopach. Określono wpływ narciarstwa na zespoły mechowców żyjących w obrębie tras narciarskich w TPN i na terenach sąsiadujących.

INTRODUCTION

THE AIM OF THE RESEARCH

This research was undertaken as part of the Program of the Institute of Nature Conservation of the Polish Academy of Sciences in Cracow to observe the consequences of the tourist pressure on the territory of Tatra National Park (TNP), especially the existing ski trails which have been intensively used for the past 50 years. In these places physical damage to vegetation and soil surface exists.

The aim of our work was oribatid mite fauna research in the environs of Zakopane, especially in the TNP, of its structure, similarity with the fauna of neighbouring regions and estimation of its changes due to human impact on the ski trails. This is the first time that the oribatid mite fauna has been used as an indicator of the state of natural landscapes in the Polish Tatra Mountains.

LITERATURE REVIEW

Many times individual notes about finding some species of oribatid mites on the territory of the TNP have been published. According to Olszanowski et al. (1996), nowadays 65 species of oribatid mites are known in this area. Unfortunately the author did not have a chance to read this paper. All the material known up to the mid-80s was compiled in a paper by W. Cichocki (Cichocki 1984) which was used in my article for completing the species list. Thirty six species belonging to 19 genera in 7 families were mentioned in it.

The microarthropode fauna in the Slovakian part of the National Park also is explored. Material about it was gathered in a faunistic list not long ago (Stary et al. 1996). Over 80 species are mentioned for this territory.

The oribatid mite fauna of the lowland areas of Poland was thoroughly explored, the works of A. Rajski and J. Rafalski should be noted especially (Rajski 1961, 1967, 1968a, 1968b, 1970, 1971; Rafalski 1966). They have studied the population of oribatid mites in the Poznań environs and Białowieża. Also data about other locations of 170 species found in the Poznań environs within Poland and abroad is given. Here we find the typology of their natural habitats which was used in our research for the population structure analysis of the oribatid mites.

The role of the oribatid mites as ecological indices was also explored (Niedbała 1978, 1983). The groups of the stenotopic species characterise a determined type of habitat. It was shown that in degraded soils the community structures undergo characteristic changes.

MATERIAL AND METHODS

The collection of material was held in September 1995 in the environs of Zakopane. Samples were obtained in two places: the Gubałówka range located to the north of that town and partially within its borders, and in the TNP located to the south. Over 100 samples of litter and soil were taken in 30 locations, which covered all the main biotopes of this area (Fig. 1). After identification, over 50 species of oribatid mites belonging to 35 genera of 27 families were found (Table 1). In total about 3000 mites were identified.

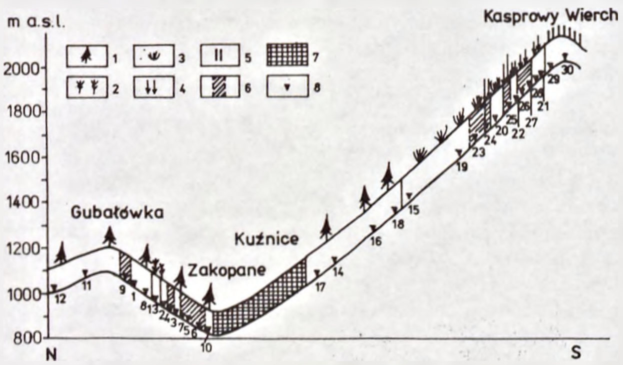

Fig. 1. The location of sampling sites in the vegetation belts on schematic profile through the Northern macroslope of the Polish Tatra Mts and Gubalowka. Vertical scale: 1:10,000. 1– coniferous forests, 2 – meadows in the forest belt, 3 – dwarf pine bushes, 4 – subalpine meadows, 5 – alpine meadows, 6 – ski trails, 7 – towns and villages, 8 – sampling sites (1–30).

Ryc. 1. Położenie miejsc pobierania prób w piętrach roślinnych na schematycznym przekroju przez północny makroskłon Tatr Polskich i Gubałówkę. Skala 1:100000. 1 – lasy szpilkowe, 2 – polany reglowe, 3 – zarośla kosodrzewiny, 4 – subalpejskie łąki, 5 – alpejskie łąki, 6 – trasy narciarskie, 7 – miasta i wsie, 8 – miejsca poboru prób (1–30).

In each location where samples were obtained, litter was taken, and in case of it's absence – the upper 5 cm layer of soil. In the locations 3–5 100×100 cm samples of litter or 5 5cm cubes of soil were taken at random.

The extraction of mites from the substratum was performed in Tulgren eclectors into 96% alcohol. Part of the material obtained was fixed on slides in Faure liquid.

After identification, the average density of certain species accounted per 1 m^2 were calculated.

For processing and analysis of the data obtained, a method based on the ideas of Braun-Blanquet for vegetation was used.

Work was performed in the following way. Species were first placed in the summary table according to their systematic position (Table 1). Then constancy locations were accounted for each species and the species were sorted according to their value; thus a table of constancy was compiled (Alexandrova 1969). For the following division of locations we did not use species with a very high (>70%) or very low (<7%) constancy. The differential species for the groups of samples were found according to the following criteria: constancy within a group of locations is higher than 50% and less than 10%, i.e. 1–2 locations outside it. Then the locations were grouped according to their faunistic similarity, as shown in Table 2. The locations with a mixed complex of species were noted especially.

Also for all the matrix of locations an attempt was made to account for the differentiation coefficient on the basis of the canonic Preston equation:

$$N^{z}_{a+b} = N^{z}_{a} + N^{z}_{b}$$

where N_a and N_b – the numbers or species in the two lists compared, N_{a+b} – the number of common species in them, z– the constant value according to Preston. It can vary from 0 to 1. If the value of „z" exceeds 0.27, the locations belong to genetically different systems; if it is less then 0.27 the locations are the part of the whole (Ogureeva 1991).

To simplify the calculation of Preston's coefficient an IBM computer programme was written. It offers us an estimated value of „z" on the basis of the entered ratios N_a/N_{a+b} and N_b/N_{a+b} with accuracy to 0.001. The algorithm of the programme is based on the method of half-division. To present the distribution of „z" in the matrix of locations the program Surfer 4.06 was used.

RESULTS AND DISCUSSION

FAUNA OF THE POLISH TATRA MTS. AND THE ENVIRONS OF ZAKOPANE

The author has found the representatives of 20 families, which are mentioned for the first time for the Polish part of the TNP. Among the already known families, some new genera and species for this location were found. Thirty new species for the territory of the park were identified, as well as 34 new species for the southern slope of Gubałówka. Also some species previously noted here were collected, for example *Carabodes labyrinticus*, *Tectocepheus velatus*, and *Edwardzetes edwardzii*. Now the list of species living within the territory of the park is full enough to be compared with other locations of faunistic investigations in this region.

Taking into account data from the literature, the fauna of Zakopane environs contains not less than 85 species (Table 1). Among the species with a known type of distribution, Holarctic (8 species) and Temperate-Holarctic Alpine

(7 species) prevail (Rajski 1970). Also the Euro-West Siberian and West-Temperate-Holarctic are represented (5 and 4 correspondingly). West-European (2 species), Subbipolar (2 species) and Subcosmopolitan groups (2 species) are also represented. Also one species each of Euro-Siberian and Holoeuropean were noted (Rajski 1970). Unfortunately there is not enough data available to show the structure of the entire fauna but we can assume that the Alpine and Holarctic species predominate.

Let us note that the presence of Polish Tatra ridge, which stretch from west to east, probably limits the penetration of many species from the south because the forest cover is broken by the alpine and subalpine belts in the higher parts of the mountains.

To learn about the relations of the oribatid mite fauna on the northern slope of Tatras in the environs of Zakopane with the adjacent territories, an attempt was made to compare the faunistic data obtained with the material known in the locations from both sides of Carpathians from both the plains and mountains (Table 1).

It was ascertained that the basis of mountain fauna consists of the species typical of the lowland part of Poland. The environs of Zakopane and the environs of Poznan have 32 common species (Table 1). It is also noticeable that *Hermannia gibba* – dominant in the TNP forest and dwarf pine zones is absent on the plains. The area studied and the environs of Brest have sixty common species (Karppinen, Krivolutsky 1982).

Comparison with locations in the Slovakian part of the Tatra National Park (TANAP) shows us 41 common species (Table 1) (Stary et al. 1996). But there is very little similarity with the plains lying to the south. Thus the complex of species which has formed in the studied territory has common features with those of the plains situated to the north but at the same time remaining a specific "montane" community common in all Tatras. Also many common species were found in this area and the Eastern Carpathians (Karppinen et al. 1992).

THE COMMUNITY STRUCTURE OF THE ORIBATID MITES IN THE TNP AND ZAKOPANE ENVIRONS

In the area studied the base of the oribatid mite community is formed by a few eurybiotic species found everywhere which can reach very high density under optimal conditions. They are: *H. gibba*, *Adoristes ovatus*, *Oribatula tibialis*, *Fuscozetes setosus*. For example the density of *H. gibba* may exceed 10,000–15,000/m² and constitute 2/3 of the total mite community. Taking into account the relatively huge size and weight of this species, it can be said that it is dominant in biomass as well. But it doesn't reach the highest parts of the mountains occupied by the subalpine and alpine meadows. These species do not play a role in distinguishing territory divisions at the local level, but might be used as the indicators of antropogenic impact on the natural systems.

Some species also show broad distribution but their constancy in the sum of samples is low. Then two groups of species according to their ecological preferences, were di-

Table 1. The list of oribatid mite species of Zakopane environs compared with some other sites. P – environs of Poznań, TS – Tatranský Narodný Park (Slovakia), EC – Estern Carpathians.

Tabela 1. Lista gatunków mechowców okolic Zakopanego na tle innych terenów. P – okolice Poznania, TS – Tatranský Narodný Park (Słowacja), EC – Karpaty Wschodnie.

Zakopane environs Okolice Zakopanego	P	TS	EC
1	2	3	4
Fam. *BRACHYCHTONIIDAE* Balogh, 1943			
Brachychtonius berlesei Willmann, 1928*			+
*B. marginatus Forsslund, 1942**			
B. immaculatus Forsslund, 1942*			+
B. jugatus f. *suecica* Forsslund, 1942*			+
B. zelawaiensis (Sellnick, 1929)*			
Synchthonius crenulatus (Jacot, 1938)*			+
Liochthonius gisini (Schweizer, 1948)*			
L. hystricinus (Forsslund, 1942)*			
L. lapponicus (Tragardh, 1910)*			+
L. muscorum Forsslund, 1964*			+
L. perpusillus (Berlese, 1910)*			+
L. sellnicki (Thor, 1930)*			+
L. propinquus Niedbala, 1972*			
L. strentzkei Forsslund, 1963*			
L. tuxeni (Forsslund, 1957)*			
Fam. *PHTHIRACARIDAE* Petry, 1841			
Phthiracarus globosus (C. L. Koch, 1841)	+	+	+
Steganacarus striculus (C. L. Koch, 1836)	+	+	+
Tropacarus carinatus (C. L. Koch, 1841)	+		
Fam. *NOTHRIDAE* Berlese, 1896			
Nothrus borrussicus Sellnick, 1928		+	+
N. *palustris* C. L. Koch, 1839	+	+	+
Fam. *CAMISIIDAE* Oudemans, 1900			
Camisia biurus (C. L. Koch, 1839)	+	+	+
C. biverrucata (C. L. Koch, 1839)			+
C. lapponica (Tragardh, 1910)*			+
Platynothrus peltifer (C. L. Koch, 1839)	+	+	+
Fam *NANHERMANNIIDAE* Sellnick, 1928			
Nanhermannia coronata Berlese, 1913	+	+	+
N. nanus (Nicolet, 1855)	+		+
Fam. *HERMANNIIDAE* Sellnick, 1928			
Hermannia gibba (C. L. Koch, 1839)		+	+
H. sp.			
Fam. *DAMAEIDAE* Berlese, 1896			
Belba corynopus (Hermann, 1804)*		+	+
B. compta (Kulczyński, 1902)*		+	
B. gracilipes (Kulczyński, 1902)*			+

Table 1 cont.

1	2	3	4
Epidamaeus tatricus (Kulczyński, 1902)*		+	+
Metabelba rohdendorfii B.-Z., 1967		+	+
M. sp.			
M. pulverulenta (C. L. Koch, 1839)*			+
M. propexa (Kulczyński, 1902)*		+	+
Fam. *CEPHEIDAE* Berlese, 1896			
Cepheus sp.	+	+	+
Conoppia microptera (Berlese, 1885)			+
Fam. *EREMAEIDAE* Sellnik, 1928			
Eremaeus oblongus C. L. Koch, 1836	+	+	+
Fam. *GUSTAVIIDAE* Oudemans, 1900			+
Gustavia microcephala (Nicolet, 1855)			
Fam. *LIACARIDAE* Sellnick, 1928			
Adoristes ovatus (C. L. Koch, 1840)	+	+	+
Liacarus coracinus (C. L. Koch, 1840)	+	+	+
Fam. *PELOPPIIDAE* Balogh, 1943			
Ceratoppia bipilis (Hermann, 1804)	+	+	+
Fam. *CARABODIDAE* C. L. Koch, 1837			
Carabodes labyrinthicus (Michael, 1879)	+	+	+
C. sp.			
Fam. *NIPHOCEPHEIDAE* Trave, 1969			
Niphocepheus nivalis (Schweizer), 1922			
Fam. *TECTOCEPHEIDAE* Grandjean, 1954			
Tectocepheus velatus (Michael, 1880)	+	+	+
T. sp.			
T. alatus Berlese, 1913*			+
Fam. *OPPIIDAE* Grandjean, 1954			
Oppia ornata Oudemans, 1900	+		
O. subpectinata (Oudemans, 1900)	+	+	
O. translamellata (Willmann, 1923)	+		+
O. unicarinata Paoli, 1908	+		
Oppiella falcata (Paoli, 1908)			+
Fam. *QUADROPPIIDAE* Balogh, 1983			
Quadroppia quadricarinata (Michael, 1885)	+	+	+
Fam. *SUCTOBELBIDAE* Jacot, 1938			
Suctobelba trigona (Michael, 1880)		+	+
Fam. *SCUTOVERTICIDAE* Grandjean, 1954			
Scutovertex minutus (C. L. Koch, 1836)			+

Table 1 cont.

1	2	3	4
Fam. *ORIBATULIDAE* Thor, 1929			
Oribatula tibialis (Nicolet)	+	+	+
Paraleius leontonychus (Berlese, 1910)*			+
Fam. *PROTORIBATIDAE* J. & P. Balogh, 1984			
Protoribates variabilis Rajski, 1958			+
Fam. *SCHELORIBATIDAE* Grandjean, 1953			
Liebstadia similis (Michael, 1888)	+	+	+
Scheloribates confundatus Sellnick, 1928		+	+
S. laevigatus (C. L. Koch, 1836)	+	+	+
Fam. *CERATOZETIDAE* Jacot, 1925			
Edwardzetes edwardsi (Nicolet, 1855)*		+	+
Fuscozetes setosus (C. L. Koch, 1839)	+	+	+
Melanozetes mollicomus (C. L. Koch, 1839)		+	+
M. meridianus (Sellnick, 1928)*		+	+
Trichoribates trimaculatus (C. L. Koch, 1836)	+	+	+
Fam. *CHAMOBATIDAE* Thor, 1938			
Chamobates shuetzi (Oudemans, 1902)	+		+
Ch. borealis (Tragardh, 1902)*		+	+
Fam. *MYCOBATIDAE* Grandjean, 1954			
Minunthozetes pseudofusiger (Schweizer, 1922)	+	+	+
Mycobates bicornis (Strenzke, 1954)*			
Puntoribates punctum (C. L. Koch, 1839)	+		+
Fam. *PHENOPELOPIDAE* Petrunkevitch, 1955			
Eupelops auritus (C. L. Koch, 1839)		+	+
E. tardus (C. L. Koch, 1836)	+		
Peloptulus phaenotus (C. L. Koch, 1844)	+	+	+
Fam. *UNDULORIBATIDAE* Kunst, 1971			
Unduloribates undulatus (Berlese, 1914)*		+	
Fam. *ORIBATELLIDAE* Jacot, 1925			
Oribatella calcarata (C. L. Koch, 1835)	+	+	+
Fam. *ACHIPTERIIDAE* Thor, 1929			
Achipteria coleoptrata (Linnaeus, 1758)	+	+	+
Fam. *GALUMNIDAE* Jacot, 1925			
Galumna sp. I			
G. sp. II			

+ – species common for the sites.
* – note: species given according to the article by W. Cichocki (1984).
(System is given according to *Panzirniye klesci*, ed. D. A. Krivolutsky, 1995).

Table 2. Density of particular species (ind./m²) in samples 1–30 (samples grouped according to their faunistic similarity on the basis of Braun-Blanquet method).

Tabela 2. Zagęszczenie poszczególnych gatunków (szt./m²) w próbach 1–30 (próby uszeregowano w/g ich faunistycznego podobieństwa w oparciu o metodę Braun-Blanqueta).

Species / Gatunek — Sample / Próba	4	5	6	7	13	1	2	3	8	9	11	14	16	17	18	10	12	19	25	28	30	26	20	22	23	24	27	29	15	21
Hermannia gibba	200	1580	–	160	363	4500	2175	13600	6420	5200	14652	10989	12378	1419	4575	2280	5820	1683	20526	9537	–	33	66	–	33	–	9537	–	–	–
Adoristes ovatus	240	160	–	–	561	450	875	220	5000	400	6930	495	198	–	–	40	99	330	395	395	–	30	163	–	297	–	–	130	–	135
Oribatula tibialis	80	300	–	240	594	950	725	1200	1500	1200	99	33	–	–	–	–	–	1980	594	–	165	35	100	–	627	–	–	65	33	67
Fuscozetes setosus	–	–	–	–	–	100	200	200	160	100	1386	–	–	–	–	–	3564	–	2900	462	297	790	30	950	–	1551	2605	–	66	268
Metabelba rhodendorfi	–	–	–	–	330	200	275	560	180	180	297	297	759	1848	875	800	693	363	–	230	100	–	–	–	–	–	–	–	–	135
Ceratoppia bipilis	–	–	–	–	–	425	–	340	980	–	66	99	33	792	–	120	198	132	330	–	132	792	231	–	–	–	–	–	33	–
Oppia translamellata	–	–	80	–	–	1000	–	4000	1000	–	–	–	4950	825	1875	–	2310	1287	330	195	595	2310	–	–	–	–	–	–	33	–
Liacarus coracinus	–	–	–	–	–	–	175	60	20	40	–	–	1980	33	–	20	–	–	200	231	–	100	–	–	–	–	–	–	–	–
Oppia unicarinata	100	2000	–	–	–	–	500	–	2000	–	5940	–	–	–	–	–	–	–	660	165	–	990	65	–	–	–	–	–	–	200
Tropacarus carinatus	360	80	–	–	99	5500	1050	2000	4000	1620	6138	3300	330	3960	–	2040	–	–	330	–	–	–	–	–	–	–	–	–	–	–
Gustavia microcephala	–	20	–	–	–	50	225	80	140	120	33	429	1056	66	75	–	33	–	–	–	–	–	–	–	–	–	–	–	–	–
Achipteria coleoptrata	380	860	–	–	297	2200	–	2260	3340	300	–	–	5346	–	50	20	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Phthiracarus globosus	160	–	–	–	–	–	–	400	2480	680	1485	2343	–	2574	–	1220	2640	1820	760	690	–	–	–	–	35	30	–	–	132	–
Tectocepheus velatus	–	–	–	–	–	–	–	–	–	–	–	3894	5148	363	–	–	297	5379	990	3370	1155	1650	–	50	35	330	4917	330	–	67
Platynothrus peltifer	420	160	–	–	33	–	–	–	–	–	–	1749	–	594	3350	1387	640	–	–	627	–	–	–	–	297	330	627	33	–	201
Oppia subpectinata	–	–	–	–	66	–	–	–	–	2600	990	3300	–	1650	750	6000	2640	–	330	–	–	–	–	–	100	495	–	–	–	–
Scheloribates confundatus	–	–	–	–	–	–	–	60	–	–	–	–	–	–	–	–	99	198	65	65	65	30	65	1000	330	–	–	132	–	–
Metabelba sp.I	–	–	–	–	–	–	–	–	–	–	–	–	33	1650	150	–	33	1650	–	–	165	–	100	50	35	–	695	–	–	200
Damaeidae ?	20	–	–	–	–	–	–	–	120	–	–	–	66	–	–	20	33	33	66	30	–	–	–	–	–	–	30	–	–	67
Melanozetes multicomus	–	–	–	–	–	–	500	–	–	–	–	–	–	–	–	160	990	–	990	35	66	660	–	–	–	6468	130	–	–	–
Chamobates shuetzi	–	–	–	–	–	–	–	–	–	–	–	–	–	495	3750	–	–	200	100	–	297	–	1650	200	–	35	–	–	–	–
Tectocepheus sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	260	–	–	–	1550	165	2970	–	–	365	8448	–	65	–	–
Eupelops tardus	800	1480	–	–	–	–	–	–	–	–	–	–	–	–	–	–	990	–	–	–	33	430	–	–	–	369	100	–	33	–
Camisia biverrucata	–	–	–	–	–	–	–	60	–	–	–	–	924	–	–	–	33	–	65	–	–	100	–	–	–	–	100	–	–	268
Nanhermannia nana	100	100	–	–	–	25	–	–	40	160	–	–	–	–	–	–	231	–	264	–	–	–	–	–	–	–	–	–	–	–
Cepheidae	–	–	–	–	–	–	25	–	80	–	–	33	1188	–	–	–	–	–	132	725	–	–	–	–	–	–	–	–	–	134

Table 2. cont.

	4	5	6	7	13	1	2	3	8	9	11	14	16	17	18	10	12	19	25	28	30	26	20	22	23	24	27	29	15	21
Conoppia microptera	–	–	–	–	–	1250	1250	–	400	–	–	–	–	–	625	400	–	–	–	–	–	–	–	150	–	35	–	–	–	–
Carabodes labyrinthicus	–	–	–	–	–	–	–	–	–	–	66	–	132	–	–	–	–	198	–	230	33	–	66	–	–	–	–	–	–	3350
Carabodes sp.	–	–	–	–	–	–	–	–	–	–	99	–	99	33	25	–	–	33	–	65	–	–	–	–	–	–	–	–	–	5360
Puntoribates punctum	780	600	–	1760	–	–	–	–	–	20	–	99	231	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	335
Steganacarus striculus	–	–	–	–	–	–	–	–	–	–	–	1650	15807	–	2475	–	–	1815	–	–	–	–	35	–	–	–	–	–	990	–
Eremaeus oblongus	–	–	–	–	–	125	–	320	–	–	–	–	1815	–	300	100	–	–	30	–	–	–	–	–	–	–	–	–	–	–
Metabelba sp.II	–	–	–	–	–	–	–	–	–	–	–	–	–	66	–	–	–	99	165	65	66	–	–	–	–	–	–	–	–	–
Sheloribates laevigatus	200	980	–	–	2277	–	–	–	–	1200	–	–	–	–	–	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Eupelops auritus	–	–	–	–	–	–	–	–	–	–	–	–	132	–	–	–	–	198	–	–	–	66	132	–	–	–	–	–	–	470
Oppia ornata	–	2000	–	–	–	–	–	–	2000	2000	–	–	–	–	–	2000	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Camisia biurus	–	–	–	–	–	–	–	–	20	–	–	–	33	–	–	–	–	33	–	–	–	–	1750	–	–	–	–	–	–	–
Edwardzetes edwardsi	–	–	–	–	–	–	–	–	–	–	–	66	–	–	100	20	–	–	–	–	–	–	–	–	–	–	–	–	198	–
Nothrus borrussicus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	66	–	–	–	–	–	–	–	–	2740	–	–	938
Quadroppia quadricarinata	–	–	–	–	–	–	–	800	–	–	–	–	4950	825	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Suctobelba trigona	–	–	80	–	–	–	–	–	–	–	3960	–	–	–	–	–	–	–	–	–	–	–	–	–	530	–	–	–	–	–
Brachuchtonius sp.	60	–	–	–	–	–	–	–	–	140	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nothrus palustris	–	–	–	–	1683	–	–	–	–	20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Minunthozetes pseudofusiger	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	120	–	–	–	–	–	–	–	50	–	–	–	–	–	–
Oribatella calcarata	–	–	–	–	–	–	–	–	–	–	–	–	198	–	–	560	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Scutovertex minutus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	429	–	–	–	–	–	–	–	–	–	–
Nanhermannia coronata	–	–	–	–	–	–	–	–	1420	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hermannia sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	33	–	–	–	–	–	–	–	–
Protoribates variabilis	–	–	–	–	–	–	–	120	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Galumna sp.I?	–	–	–	–	–	25	–	–	–	–	–	–	–	264	–	–	132	–	–	–	–	–	–	–	–	–	–	–	–	–
Galumna sp.II?	–	–	–	–	–	–	–	–	–	–	–	–	–	400	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Niphocepheus nivalis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	140	–	–	–	–	–	–	–	–	–

stinguished: those preferring certain biotopes and reaching high density within them, and species of random distribution, with low constancy and density. The distribution of mites in different habitats can be seen in Fig. 1 and Table 2.

The analysis of the summary table according to the Braun-Blanquet method shows us the presence of two groups of species. The representatives of the first one are typical of the forests and of the second are found mainly in subalpine and alpine landscapes (Table 2). A wide zone of copenetration of these two complexes is observed. The first group includes *Metabelba rohdendorfi*, *Ceratoppia bipilis*, *Oppia translamellata*, *O. unicarinata*, *Liacarus coracinus* and *Tropacarus carinatus*. The second one contains *Scheloribates confundatus*, *Melanozetes mollicomus*, *Chamobates shuetzi*, *Tectocepheus velatus* and some others.

The overlap of the "forest" and "montane" groups is observed at altitudes 1000–1800 m a.s.l. Penetration of forest species into the subalpine belt, higher than the actual timberline may have the following explanation: these are in fact relic communities which have preserved their structure after man lowered the upper timberline by about 200 m (Skawiński 1993).

At the lower part of the slope the community of oribatid mites is represented only by the "forest" group. The following situation is observed: as a rule in the relatively undisturbed biotopes 12–20 species were found in each location (Fig. 2). *H. gibba*, *T. carinatus*, *A. coleoptrata*, *O. translamellata* dominate. Species diversity increases close to the springs (sites 3, 10). The quantity and biomass of microarthropodes reach maximal values there due to the constant humidity. It was there where the highest density of the oribatid mites (57,000 ind./m^2) for this area was noted. When speaking of the lateral differentiation in the structure of the microarthropodes communities in the forest belt, it is evident that in the Tatra National Park the average number of species is higher than on non-protected territories which are under more intensive usage by man (Table 2).

Moving higher in the mountains close to the upper timberline the structure of the oribatid mites communities changes. In the forests made up of the European spruce (*Picea abies*) and rowan (*Sorbus aucuparia*) representatives of the "forest" group of mites greatly decrease in density. But we still find here *M. rohdendorfi*, *O. translamellata*, *A. coleoptrata*, *G. microcephala*.

The specific complex of species is observed in meadows within the forest belt which are not visited by tourists and are not used as pastures. The vegetation is represented by the gramineous communities. The "montane" species of the oribatid mites were not found there, the forest group having been impoverished as well (sample site 13, Table 2). The dominant species of the meadows are found irregularly in the other biotopes (*Scheloribates laevigatus*). It was there that the characteristic species *Nothrus palustris* was found in representative quantity (one more find of this mite was on the ski trail – sample site 9, but it was a single individual). Here it reaches a density of about 1,700 mites/m^2. Instead of immature larvae, nymphs of different ages were also found. It tells us about the stable and self reproducing population of *N. palustris* existing in the meadow. It was surprising for

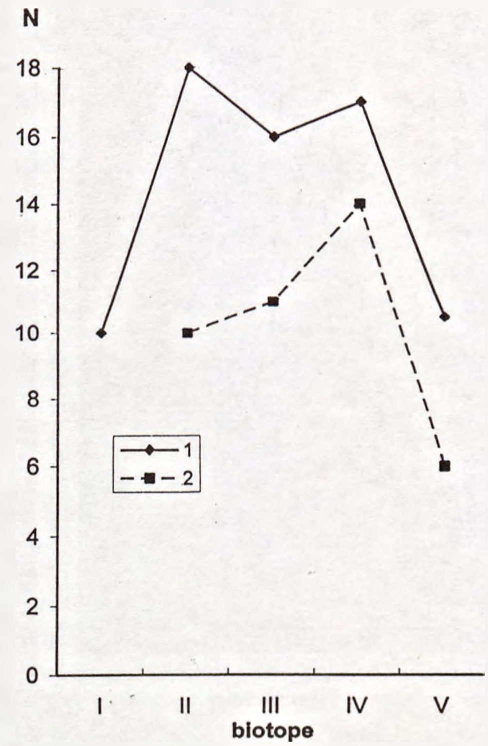

Fig. 2. The average number of species (N) in a sample in different biotopes. I – meadows in the forest belt; II – forests; III – dwarf pine bushes; IV – subalpine meadows; V – alpine meadows; 1 – undisturbed biotopes; 2 – ski trails.

Ryc. 2. Średnia liczba gatunków (N) w próbie w różnych biotopach. I – łąki w pasie regli; II – regle; III – zarośla kosodrzewiny; IV – subalpejskie łąki, V – alpejskie łąki; 1 – nienaruszone biotopy; 2 – trasy narciarskie.

us to find it only in the meadows and nowhere else because according to literature data it prefers forest landscapes (Krivolutsky ed. 1995).

In the higher parts of the mountains superposition of the two groups of species is observed. The "forest" group still plays a significant role in the community structure but the "montane" species appear as well. The average species diversity in the dwarf pine bushes (*Pinus mugo*) decreases to 16 species per sample and to 17 species in the subalpine meadows (Fig. 2). The total density of the oribatid mites decreases from 25,000 in the forests to 8–9 thousand ind./m^2 (Fig. 3).

Any notable difference between the species list in the samples from the dwarf pine bushes and the open territories have not been noted but the average density of the oribatid mites is higher in the meadows. We noted that the layer of litter, consisting mainly of needles, below the dwarf pine is very thick (up to 12 cm). But in spite of this fact only a few mites of the *Ptyctima* group survive, known as consumers of pine needles (Krivolutsky ed. 1995). Such numerous species in the forest as *Tropacarus carinatus*, *Phthiracarus globosus* were not found there (Table 2). Only *Steganacarus striculus* was noted. Possibly the conditions for these species in the subalpine belt are rather severe. Within the subal-

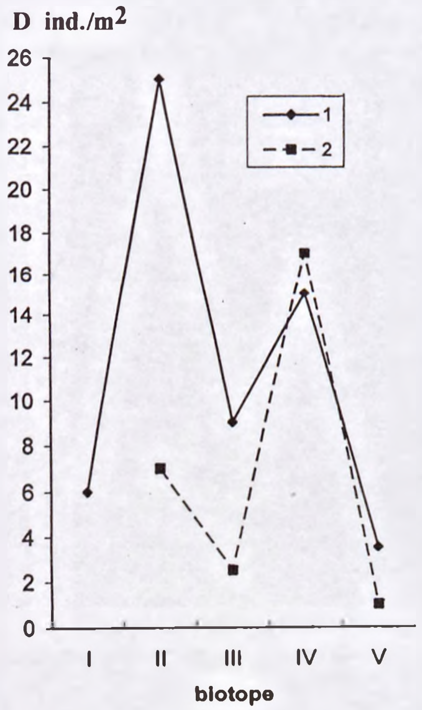

Fig. 3. The average density D (in thousand ind./m²) of the oribatid mites in a sample in different biotopes. Explanations as in Fig. 2.

Ryc. 3. Średnie zagęszczenie D (w tysiącach osobników/m²) mechowców w próbie w różnych biotopach. Objaśnienia jak na ryc. 2.

pine belt this fact also helps the accumulation of organic matter in litter which is not decomposed also due to the total decrease of biological processes.

When climbing higher into the mountains in the subalpine belt the role of the "forest" group decreases and representatives of the "mountain" group begin to dominate (*Sch. laevigatus*, *M. multicomus*, *Ch. shuetzi* etc.). The density of eurybiotic species also decreases.

The Preston difference coefficient accounting within all the matrices of the samples showed us the situation as in Fig. 4. The total distribution scheme of "z" in the sum of samples indicates the species lists of samples collected in similar biotopes have a greater similarity. For example within the spruce forest biotopes (locations 1, 2, 3, 14, 16, 17) "z" is usually not higher than 0.6. "Z" increases between samples from the forest belt and subalpine belt. Here the values of z=0.8 are more typical (for example between locations 22, 29, 30 from subalpine and alpine belts and locations 1, 2, 3, 14, 16).

Almost all situations when "z" between two locations is equal to 1 (which means that the species lists are absolutely different) are connected with samples from the ski trails (location 6, 7 in comparison with many others). This results from the fact that the species list from these places is very poor and doesn't include many of the species constantly found on the whole territory. We can say that instability of the "z" value in the matrix tells us about disturbance of the observed oribatid mite community in comparison with the others. Very interesting is location 22 from the moss of the alpine belt. It looks to be the most unique. It is seen that "z" between this location and all the forest locations is higher than 0,8 and very often is equal to 1 (Fig. 4).

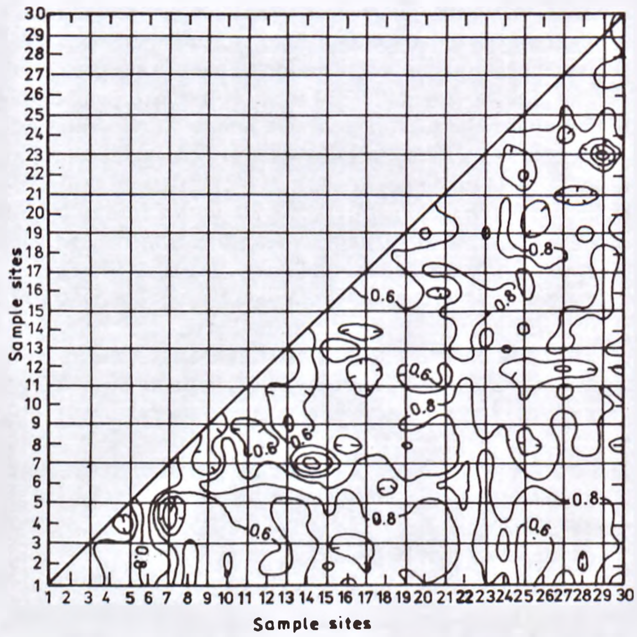

Fig. 4. The distribution of Preston coefficients in the matrix of locations.

Ryc. 4. Rozkład współczynników Prestona w macierzy stanowisk.

ANALYSIS OF CHANGES IN THE ORIBATID MITE COMMUNITIES UNDER ANTHROPOGENIC PRESSURE ON THE EXAMPLE OF SKI TRAILS

When using the slopes of mountains as ski trails a total decrease in species diversity is observed. Same happens with population densities (Fig. 3). This is seen more clearly in the forest belt where these criteria may vary in many times between the forest and the ski trails (25,000 and 680 ind./m² correspondingly). This degradation is probably determined not only by the winter usage of the area by skiers when the litter and soil are protected from physical disturbances by a thick layer of snow but the summer usage of the ski trails as pastures which results in the compression of soil, destruction of litter and destruction of the upper soil layer enriched with microfauna in undisturbed conditions. Moreover, when creating the ski trail, cuttings are inevitable which also decreases bioproductivity of the territory and as a result lowers the volume of litter – the food base of the soil microflora and microfauna. Hence the stream of matter in this system becomes thin resulting in its further destabilization.

The comparison of species diversity of the oribatid mites in undisturbed biotopes and on the ski trails shows us an overall reduction in all ski used habitats (Fig. 2). We can also see the levelling of differences between the belts in the mountains (Fig. 2). Here usually 10–11 species per sample are found in comparison with 18 species in the forests and 14–16 in the subalpine and alpine belts (Fig. 2). This is likely to be related to the disappearance of species most sensitive to human impact.

When analysing the massif according to the Braun-Blanquet method it is clear that the communities of oribatid mites from the ski trails, according to their species lists, cannot be included with those from the surrounding forests (Table 2). Some "remnants" of the forest communities with the specific list of species for each sample are found on the ski trails (samples 4, 5, 6, 7). The same situation is observed in sample 15 collected in the subalpine belt on a wide tourist path. Not any species specific to subalpine conditions were noted there (Table 2).

When the ski trails are closed to summer visiting and usage the disorder in structure of the oribatid mites communities is not so great. This is clearly seen in the samples from ski trails obtained within the Tatra National Park (samples 23–27) (Table 2). Only communities on the steep slopes (about 30° or more) do not obey this rule. The vegetation cover is rarefied on them and rocks are visible. Moreover, the processes of surface flow, effects of fibrous ice activity and exposure of bare soil, are very active there, especially in the thaw period; this may result in the mechanic transfer of microarthropodes to lower parts of the slope (sample 29).

The human impact on the ski trails is well indicated by the absence of many common species such as *F. setosus* or a great reduction of their population. Taking into account their high constancy outside the ski trails, it can be said that they can be used as reliable indicators of human impact and a decrease in environment quality.

A group of very sensitive species to the usage of areas as ski trails was found. It includes *M. rohdendorfi*, *C. labyrinthicus* and some others practically not found on the trails but with high constancy in undisturbed habitats.

The most indifferent species to the impact on the ski trails are *H. gibba*, *O. tibialis*, *Puntoribates punctum* in the forest belt and *T. velatus* in the subalpine and alpine belts.

We have not indicated any species as preferring ski trails, i.e. not any substitution of species occurs.

CONCLUSIONS

The decrease in species diversity of the oribatid mite communities on the ski trails in comparison with the surrounding habitats has been established. It is noted that the maximal degradation of the microarthropodes community occurs on the trails within the forest belt because of the greatest changes in the natural biotope during their construction. Maximal impoverishment of the oribatid mites community is observed on the ski trails outside the Tatra National Park where, besides their winter usage, they are subject to a whole spectrum of summer utilisation which is much more harmful for the soil microfauna communities.

Species which are good indicators of human impact on the ski trails were discovered.

On the basis of the criteria chosen in this study we can assume that the state of the natural oribatid mite assemblages on the ski trails in the Tatra National Park is still near to normal except in areas of concentration of skiers such as narrow parts of the trails, and areas near the ski lift stations and on the steep slopes in the alpine belt. The state of the ski trails outside the TNP is bad, the oribatid mite communities are almost terminated. Immediate activities for recultivation of the trails must be organised. A ban of the summer visiting of these trails and usage as pastures can be recommended.

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REFERENCES

ALEXANDROVA V. D. 1969. Klassificacia rastitelnosti. Nauka, Leningrad.

CICHOCKI W. 1984. Acarofauna Tatrzańskiego Parku Narodowego w świetle dotychczasowych badań (Acarofauna of the Tatra National Park in the light of previous research). Parki Nar. Rez. Przyr. 5, 2: 31–38.

KARPPINEN E., KRIVOLUTSKY D. A. 1982. List of oribatid mites (*Acarina, Oribatei*) of nothern palaearctic region. I. Europe Acta Entom. Fenn. 41.

KARPPINEN E., MELAMUD V. V., MIKO L., KRIVOLUTSKY D. A. 1992. Further information on the oribatid fauna (*Acarina, Oribatei*) of nothern palaearctic region. Ukraine and Czechoslovakia. Acta Entom. Fenn. 3: 41–56.

KRIVOLUTSKY D. A. (ed.). 1995. Panzirniye klesci. Nauka, Moskwa.

NIEDBAŁA W. 1978. Badania biocenotyczne nad mechowcami (*Acari, Oribatei*) masywu Ślęży. Bad. Fizjogr. Pol. Zach., ser. C – Zoologia 30: 48–73.

NIEDBAŁA W. 1983. Mechowce (*Oribatida*) jako wskaźniki ekologiczne. Zesz. Probl. Post. Nauk Rol. 252: 137–146.

OGUREEVA G. N. 1991. Botaniko-geographicheskoye rayonirovanie SSSR. Izd. MGU, Moskva.

OLSZANOWSKI Z., RAJSKI A., NIEDBAŁA W. 1996. Roztocze *Acari*. Mechowce *Oribatida*. Katalog Fauny Polskiej. Cz. 34, tom 9, nr 55.

RAFALSKI J. 1966. Materiały do znajomości fauny mechowców (*Acari, Oribatei*) Polski. I. Fragm. Faun. 12, 21: 347–372.

RAJSKI A. 1961. Studium ekologiczno-faunistyczne nad mechowcami (*Acari, Oribatei*) w kilku zespołach roślinnych. I. Ekologia. Wydz. Mat.-Przyr. Pr. Kom. Biol. 25, zesz. 2.

RAJSKI A. 1967. Autecological-Zoogeographical Analysis of Moss Mites (*Acari, Oribatei*) on the basis of fauna in the Poznań Environs. Part I. Pol. Pis. Entom. 37, 1: 69–166.

RAJSKI A. 1968a. Autecological-Zoogeographical Analysis of Moss Mites (*Acari, Oribatei*) on the basis of fauna in the Poznań Environs. Part II. Fragm. Faun. 14, 12: 278–405.

RAJSKI A. 1968b. Analiza autekologiczno-zoogeograficzna mechowców (*Acari, Oribatei*) na przykładzie fauny okolic Poznania. Wyższa Szkoła Rol. w Szczecinie. Rozprawy 10.

RAJSKI A. 1970. Autecological-Zoogeographical Analysis of Moss Mites (*Acari, Oribatei*) on the basis of fauna in the Poznań Environs. Acta Zool. Cracov. 15, 3: 161–250.

Rajski A. 1971. Autecological-Zoogeographical Analysis of Moss Mites (*Acari, Oribatei*) based on the fauna in the Poznań Environs. In: Proc. of the 3rd Internat. Congress of Acarology, Prague.

Skawiński P. 1993. Oddziaływania człowieka na przyrodę kopuły Kasprowego Wierchu oraz Doliny Goryczkowej w Tatrach (Kasprowy Wierch and Goryczkowa Valley: Human impact on nature in the Tatra Mountains). In: Ochrona Tatr w obliczu zagrożeń. Red. W. Cichocki. Wyd. Muzeum Tatrzańskiego, Zakopane, s. 197–226.

Stary J., Karppinen E., Krivolutsky D. A. (1996). List of oribatid mites (*Acari: Oribatida*) of the Slovak Republic. Msc.

STRESZCZENIE

Badano strukturę zespołów mechowców (*Acarina, Oribatei*) okolic Zakopanego i Tatrzańskiego Parku Narodowego (TPN). Próby pobierano we wszystkich siedliskach i piętrach wysokościowych w samym parku i w jego okolicy (ryc. 1). W trakcie badań przeprowadzonych we wrześniu 1995 roku stwierdzono ponad 50 gatunków należących do tej grupy (tab. 1). Spośród nich w Tatrzańskim Parku Narodowym zanotowano po raz pierwszy około 30 gatunków, a na północnych stokach Gubałówki 34 gatunki. Porównano glebową faunę microstawonogów tego regionu i terenów przyległych oraz okolic Poznania (tab. 1).

Przeanalizowano również strukturę zespołów mechowców w różnych biotopach. Wyróżniono grupę mechowców "leśnych" i "górskich". Do pierwszej grupy zaliczono *Metabelba rohdendorfi, Ceratoppia bipilis, Oppia translamellata, O. unicarinata, Liacarus coracinus* i *Tropacarus carinatus*. Druga grupa obejmuje *Scheloribates confundatus, Melanozetes mollicomus, Chamobates shuetzi, Tectocepheus velatus* i kilka innych. Są też gatunki eurybiotyczne, jak np. *Hermannia gibba, Adoristes ovatus, Oribatula tibialis, Fuscozetes setosus*.

Oceniono rolę mechowców w różnych biotopach (tab. 2). Aby uzyskać bardziej obiektywną informację o podobieństwie zespołów mechowców z różnych miejsc pobierania prób, zastosowano współczynnik Prestona (ryc. 4).

Przeprowadzono analizę wpływu turystyki na zespoły mechowców na przykładzie tras narciarskich w TPN i w okolicy. Stwierdzono obniżenie się różnorodności gatunkowej mechowców i ich zagęszczenia na trasach narciarskich w porównaniu z otaczającymi je siedliskami (ryc. 2 i 3). Maksymalną degradację zespołu tych mikrostawonogów zaobserwowano na trasach przebiegających w obrębie regli, gdyż w trakcie ich budowy zaszły tu największe zmiany w naturalnych siedliskach. Największe zubożenie zespołu mechowców zanotowano na trasach narciarskich poza terenem parku, ponieważ oprócz wykorzystywania ich w okresie zimowym podlegają one różnym formom użytkowania w okresie letnim.

Dobrymi wskaźnikami narciarskiego użytkowania terenu są m.in. *M. rohdendorfi* i *C. labyrinthicus*.

Na podstawie kryteriów przyjętych w tych badaniach można stwierdzić, że stan zespołów mechowców na trasach narciarskich w obrębie Tatrzańskiego Parku Narodowego nie odbiega zasadniczo od naturalnego za wyjątkiem miejsc koncentracji narciarzy, takich jak zwężenia tras, obszary wokół stacji wyciagów i strome fragmenty stoków w obrębie strefy alpejskiej. Stan tras narciarskich poza terenem parku narodowego jest zły, zespoły mechowców zostały tam praktycznie zniszczone. Konieczne jest podjęcie zabiegów rekultywacyjnych tych tras; nie powinny być one używane jako letnie szlaki turystyczne ani jako pastwiska.