



Biodiversity of oribatid mites (Acari: Oribatida) along an altitudinal gradient in the Central Alps

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Abstract

Oribatid mite communities were studied in the Central Alps (Oberurgl, Tyrol, Austria). Samples were taken on four sites along an altitudinal gradient from 2050 m a.s.l to 2900 m a.s.l., in different vegetation units (pine forest, Nardetum, Caricetum, Androsacetum). A total of 86 species were found, most of them occurred only at one altitude, four species were found in all four study sites. Three taxa could not be ascribed to a certain species (*Carabodes* sp. *Mycobates* sp., *Tectocephus* sp.). Species richness and density of oribatid mites decrease with increasing altitude. The results are compared with previous studies in the same region and show remarkable shifts in species composition.

Key words: Oribatida, faunistics, distribution, altitudinal gradient, species list, Central Alps, Austria

Introduction

High alpine ecosystems of the Central Alps have been a focus of research since a long time and numerous investigations with main attention on soil mesofauna have been carried out (e.g. Schweizer 1922, 1956; Handschin 1924; Schatz 1979; Schmölzer 1993; Kaufmann *et al.* 2002). Last comprehensive studies on distribution and ecology of oribatid mites in the same area of the Central high Alps have been conducted by Schatz (1978, 1979). He showed that species compositions at different altitudes are clearly distinguishable from each other. Unfortunately, there is a lack of recent studies addressing groups of mesofauna, although it would be important to monitor possible changes in species distribution, whether to address soil succession, climatic changes or other possible influences. The present study aimed to investigate the diversity and distribution of oribatid mite species along an altitudinal gradient in a high alpine region and to compare recent results with previous findings.

Material and Methods

Study sites. This study was conducted in Oberurgl/ Ötztal in the Tyrolean Central Alps. Prevailing parent rock is crystalline-slate silicate. In July 2010 samples were taken along an altitudinal gradient at four sites (2900 m, 2600 m, 2300 m and 2050 m). Descriptions of the study sites are based on Koch and Erschbamer (2010). Geographic coordinates given have been measured with a GPS (Garmin Oregon 550t).

Liebener Rippe (LR): N46°49.250', E11°03.339', 2900 m a.s.l. This rocky promontory is situated at the head of Rotmoos valley. Vegetation grows patchily, raw soils with pioneer vegetation and scarcely vegetated scree is interspersed with small-scaled grass patches and cushion plants. Typical plant communities are Androsacetum alpinae, *Sesleria ovata*-community, Elynetum myosuroides and Hygrocaricetum curvulae. Frequently occurring lichens are *Cetraria nivalis* and *Thamnolia vermicularis*. Soil developed on windblown sand.

Hohe Mut (HM): N46°50.081', E11°02.801', 2600 m a.s.l. Distinct mountain ridge above timberline with Caricetum curvulae, with shallow brown soil. Used for sheep-grazing.

Schönwieskopf (SK): N46°50.852', E11°00.967', 2300 m a.s.l. Wind exposed grass field above the timberline with a typical *Nardus stricta*-community. Occasional grazing (horses, sheep). Remnants of podsol soils with attributes of pseudogley.

Zirbenwald (ZW): N46° 51.542', E11°00.990', 2050 m a.s.l. Remnant of a *Pinus cembra*-forest with *Pinus mugo*, *Larix decidua*, *Rhododendron ferrugineum*, *Juniperus*, *Empetrum* and *Vaccinium* as understorey plants. Soil type is ferric podsol.

Sampling design and analyses. Three replicates of soil-samples with a diameter of 15 cm and depth of 10 cm were taken from each study site. Samples were transferred to the laboratory and extracted by heat and stored in ethanol (75%) until analysis. The study is based on a total of 7830 individuals.

Unless stated otherwise, the nomenclature follows Weigmann (2006). Information about distribution and habitat preferences of oribatid mite species have been obtained from Schatz (1983, updated), Weigmann (2006) and data collected by the authors. The alpha-diversity was calculated using Shannon-index (based on \log_n). The diversity-values H_s increase with increasing number of species and with increasing evenness of individuals per species. Similarities between study areas were calculated as a measure of β -diversity using Sørensen's similarity index (Sørensen 1948). It is expressed as $SI = 2C/A+B$, with A and B as number of species in the two comparing study sites and C as number of species shared by the two sites.

The comparison of recent results with previous investigations refers to Schatz (1978, 1979), hereafter referred to as "previous studies".

Results and discussion

A total of 86 species representing 30 families and 53 genera were recorded in the study sites (Tab.1). Oribatid mites were determined to species level, three taxa could not be ascribed to a certain species yet (*Carabodes* sp., *Mycobates* sp., *Tectocephus* sp.). Most species-rich families were Ceratozetidae and Oppiidae (12 species each), followed by Suctobelbidae (7 spp.) and Damaeidae, Oribatulidae and Phenopelopidae (5 spp. each). Obviously each altitude has its own species composition and only four species were recorded in all four sites (*Fuscozetes intermedius*, *Trichoribates scilierensis*, *Oribatula longelamellata*, *Tectocephus velatus sarekensis*). The majority of species were only found at one altitude (63 spp.). Except for the Nardetum (Schönwieskopf, 2300 m), the two most abundant species represent more than half of the oribatid mite community: on Androsacetum alpinae (Liebener Rippe, 2900 m) *Melanozetes meridianus* and *Oromurcia sudetica* (59%), in Caricetum (Hohe Mut, 2600 m) *Trichoribates scilierensis* and *Oribatula longelamellata* (73%) and in the pine forest (Zirbenwald, 2050 m) *Oppiella* (*Oppiella*) *uliginosa* and *Dissorhina ornata* (57%). On Schönwieskopf *Anachipteria alpina* and *Fuscozetes intermedius* represent slightly more than one third of the oribatid mite community. In all, 13% of the species are represented by a single specimen. Generally species richness and abundance decrease with increasing altitude (Fig.1). Shannon diversity-index was lowest at in Caricetum (Hohe Mut, 2600 m; H' 1,5) followed by Androsacetum alpinae (Liebener Rippe, 2900 m; H' 1.9). In the Nardetum (Schönwieskopf, 2300 m) and in the pine forest (Zirbenwald, 2050 m) H' was, according to our expectations, higher (2.2 and 2.4 respectively). The β -diversity has been calculated with Sørensen's similarity index (Fig.2). Unsurprisingly, the Liebener Rippe had the least similarity to the pine forest (SI 0.16), but the highest similarity to Caricetum at Hohe Mut (SI 0.36).

The majority of species are distributed in the whole Holarctic region (38.1%) and Europe (38.8%). Only four species seem to be restricted to the Central Alps: *Kunstidamaeus diversipilis*, *Carabodes schatzi*, *Trichoribates scilierensis* and *Tectocephus* sp. (Fig. 3).

Species identified

Brachychthoniidae Thor, 1934

Eobrachychthonius borealis Forsslund, 1942

Distribution: Europe, Asia; also Arctic

Habitat: forest soils

Obergurgl area: pine forest at 2050 m (Zirbenwald)

TABLE 1. Occurrence and relative abundance of oribatid mite species in different altitudes in Obergurgl. LR (Liebener Rippe, Androsacetum alpinae, 2900 m a.s.l.), HM (Hohe Mut, Caricetum curvulae 2600 m), SK (Schönwieskopf, Nardetum 2300 m), ZW (Zirbenwald, pine forest 2050 m). Abundances in ind./m².

	LR	HM	SK	ZW
<i>Achipteria sellnicki</i>				4127
<i>Adoristes ovatus</i>				1
<i>Anachipteria alpina</i>			2877	1647
<i>Berniniella bicarinata</i>				655
<i>Caleremaeus monilipes</i>			238	4107
<i>Camisia biurus</i>				218
<i>Camisia spinifer</i>			60	179
<i>Carabodes cf. rugosior</i>				7937
<i>Carabodes schatzi</i>			1587	198
<i>Cepheus dentatus</i>				1627
<i>Cepheus latus</i>				456
<i>Ceratoppia bipilis</i>				1
<i>Ceratozetes thienemanni</i>				3155
<i>Chamobates birulai</i>				79
<i>Chamobates borealis</i>		1		79
<i>Chamobates cuspidatus</i>				8036
<i>Chamobates voigtsi</i>				238
<i>Cymbaeremaeus cymba</i>				40
<i>Damaeus gracilipes</i>				159
<i>Diapterobates humeralis</i>				79
<i>Dissorhina ornata</i>				25377
<i>Dissorhina signata</i>				1310
<i>Edwardzetes edwardsi</i>	40			317
<i>Eobrachychthonius borealis</i>				40
<i>Epidamaeus bituberculatus</i>		1		
<i>Eueremaeus oblongus</i>				20
<i>Eupelops curtipilus</i>			377	456
<i>Eupelops plicatus</i>	60			
<i>Eupelops strenzkei</i>	378			
<i>Eupelops subuliger</i>				754
<i>Eupelops torulosus</i>			179	
<i>Fuscozetes intermedius</i>	497	40	2718	2619
<i>Fuscozetes setosus</i>		40		972
<i>Hermannia gibba</i>				40
<i>Jugatala angulata</i>				1
<i>Jugatala cribelliger</i>	437			
<i>Kunstdamaeus diversipilis</i>		99		
<i>Liacarus coracinus</i>				1
<i>Liacarus oribatelloides</i>				139
<i>Licneremaeus licnophorus</i>				1
<i>Liochthonius simplex</i>				1

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TABLE 1. (Continued)

	LR	HM	SK	ZW
<i>Malaconothrus monodactylus</i>			40	1
<i>Melanozetes meridianus</i>	2166		40	
<i>Metabelba pulverosa</i>				417
<i>Micreremus brevipes</i>				1
<i>Microppia minus</i>				317
<i>Mycobates</i> sp.		40	2361	60
<i>Oppiella (Moritzoppia) unicarinata</i>				1171
<i>Oppiella (Oppiella) falcata</i>		40	1	1885
<i>Oppiella (Oppiella) nova</i>	1	40		
<i>Oppiella (Oppiella) obscura</i>	1			
<i>Oppiella (Oppiella) uliginosa</i>				46548
<i>Oppiella (Rhinoppia) obsoleta</i>				665
<i>Oppiella (Rhinoppia) subpectinata</i>				198
<i>Oribatella longispina</i>				1091
<i>Oribatella reticulata</i>	318			
<i>Oribatula amblyptera</i>				40
<i>Oribatula interrupta</i>		40		1
<i>Oribatula longelamellata</i>	1	1766	952	218
<i>Oribatula tibialis</i>			1885	635
<i>Oromurcia sudetica</i>	1252	417		
<i>Pantelozetes paolii</i>			417	496
<i>Parachipteria punctata</i>				437
<i>Passalozetes intermedius</i>				40
<i>Phauloppia nemoralis</i>				1
<i>Phthiracarus globosus</i>				2520
<i>Phthiracarus laevigatus</i>				496
<i>Platynothrus peltifer</i>				298
<i>Porobelba spinosa</i>				99
<i>Quadroppia quadricarinata</i>				60
<i>Scheloribates laevigatus</i>	40			754
<i>Steganacarus (Atropacarus) striculus</i>			1	
<i>Steganacarus (Atropacarus) wandae</i>		1		
<i>Suctobelba altvateri</i>				119
<i>Suctobelba regia</i>				139
<i>Suctobelbella acutidens lobata</i>				813
<i>Suctobelbella hamata</i>				258
<i>Suctobelbella perforata</i>	40			
<i>Suctobelbella sarekensis</i>				198
<i>Suctobelbella subcornigera</i>				198
<i>Tectocephus</i> sp.		198		
<i>Tectocephus velatus sarekensis</i>	139	893	99	317
<i>Tectocephus velatus tenuis</i>		1	1825	179

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TABLE 1. (Continued)

	LR	HM	SK	ZW
<i>Tectocephus velatus velatus</i>			60	119
<i>Trhypochthonius tectorum</i>			60	218
<i>Trichoribates scilierenis</i>	338	3353	1	298
<i>Trichoribates trimaculatus</i>	60			119

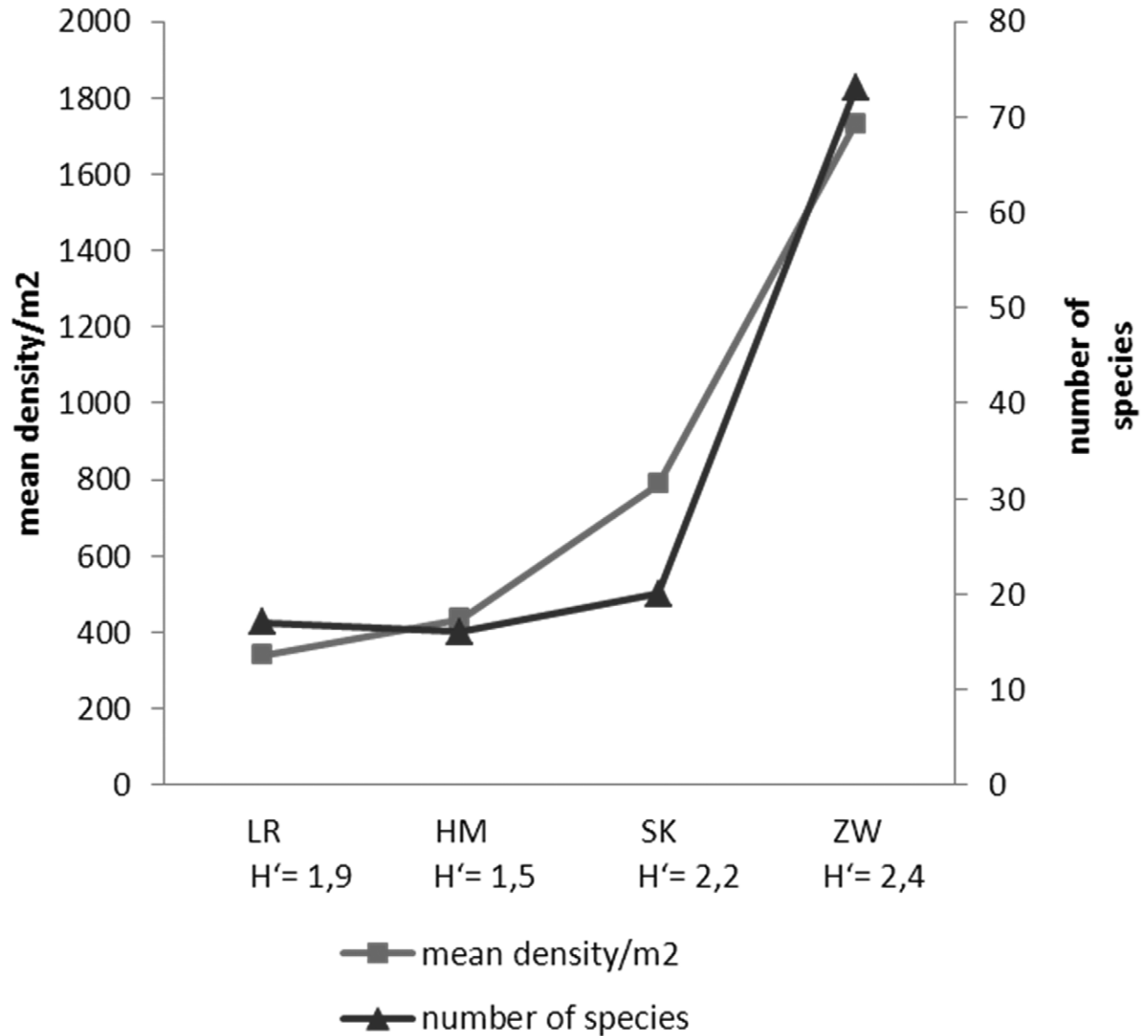


FIGURE 1. Species richness, abundance and Shannon diversity-index (H'). LR (Liebener Rippe, Androsacetum alpinae, 2900 m a.s.l.), HM (Hohe Mut, Caricetum curvulae, 2600 m a.s.l.), SK (Schönwieskopf, Nardetum, 2300 m a.s.l.), ZW (Zirbenwald, pine forest, 2050 m a.s.l.).

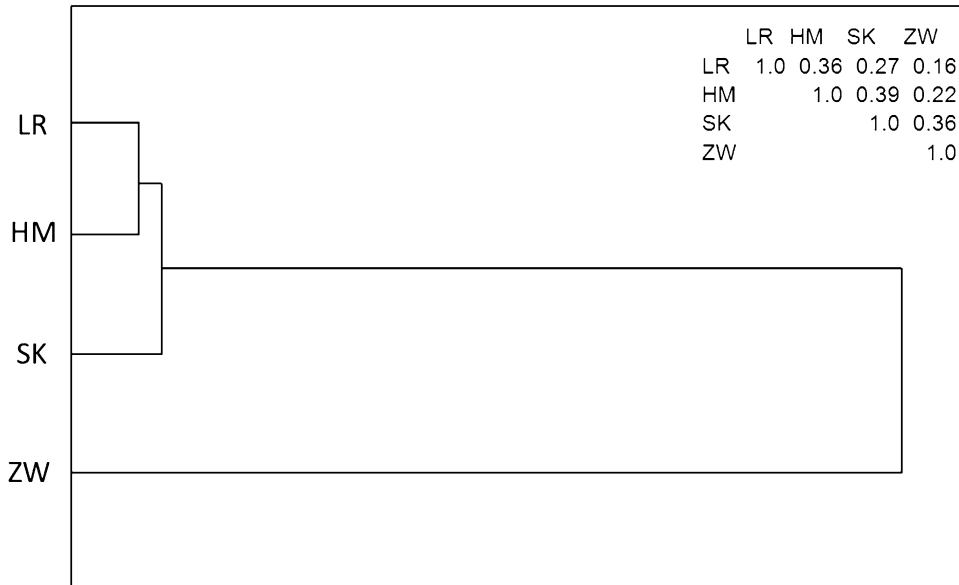


FIGURE 2. Illustration of the Sørensen's similarity index calculated for LR (Liebener Rippe, *Androsacetum alpinae*, 2900 m a.s.l.), HM (Hohe Mut, *Caricetum curvulae*, 2600 m a.s.l.), SK (Schönwieskopf, *Nardetum*, 2300 m a.s.l.), ZW (Zirbenwald, pine forest, 2050 m a.s.l.).

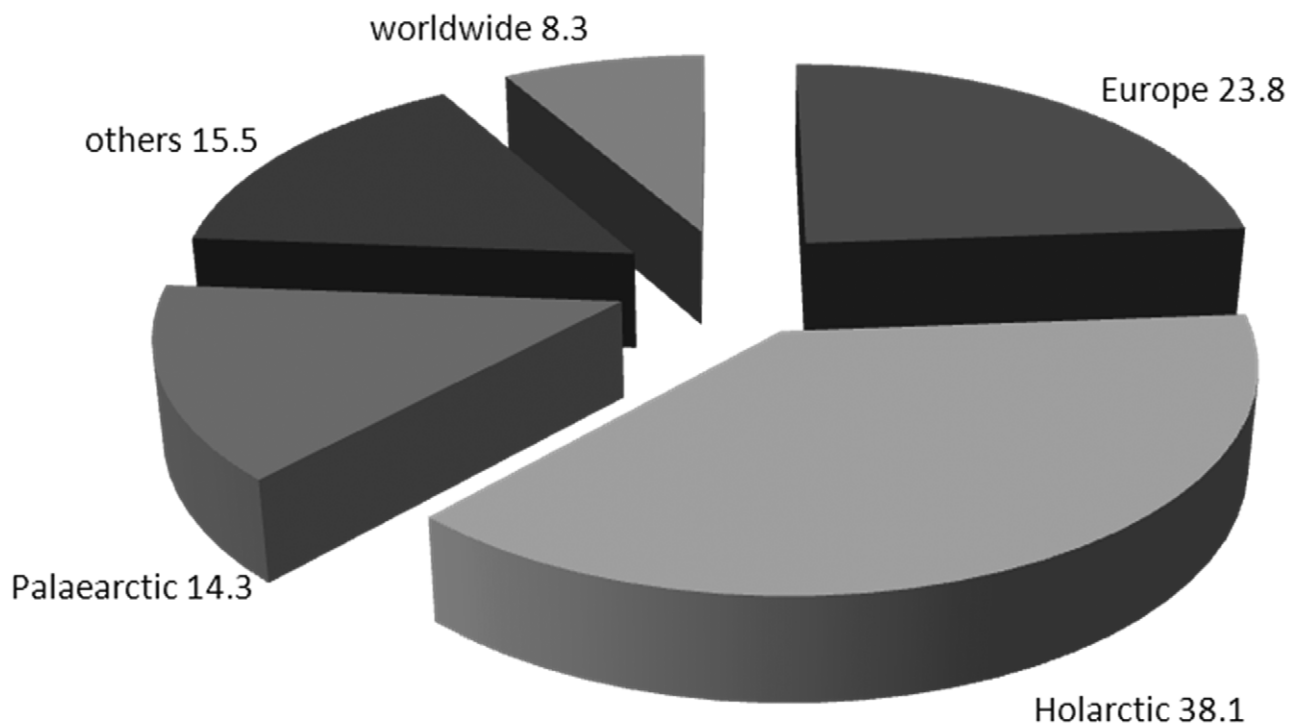


FIGURE 3. General distribution of species in %.

***Liochthonius simplex* (Forsslund, 1942)**

Distribution: Palaeartic, Greenland; East Asia, Australia

Habitat: mainly forest soils

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Remark: In the previous studies Brachychthoniidae have also been recorded at higher altitudes of Obergurgl. *Verachthonius laticeps* Strenzke, 1951 (sub. *Brachychthonius laticeps*), *Liochthonius lapponicus* (Trägårdh, 1901) and *Liochthonius sellnicki* (Thor, 1930) have been detected on Liebener Rippe in abundances of 300 to 600 individuals per m². In this study, species of this family were found only in minor quantity in the pine forest (2050 m a.s.l.). Some taxa of the family Brachychthoniidae (especially several species of the genera *Liochthonius* and *Verachthonius*) are known to occur in raw soils in high abundances (Schweizer 1956; Moritz 1976; Schatz 2004). Most probably the absence of Brachychthoniidae on Liebener Rippe in 2010 is referable to a change of the soil from raw soil to a later successional stage.

Phthiracaridae Perty, 1841

***Steganacarus (Atropacarus) striculus* (C.L. Koch, 1836)**

Distribution: Holarctic; Hawaii

Habitat: moist to wet forest, meadow- and bogsoils

Obergurgl area: Nardetum at 2300 m (Schönwieskopf)

***Steganacarus (Atropacarus) wandae* Niedbala, 1981**

Distribution: Switzerland, France, Spain, Great Britain, Denmark, Poland, Austria

Habitat: open forests?

Obergurgl area: Caricetum at 2600 m (Hohe Mut)

***Phthiracarus globosus* (C.L. Koch, 1841)**

Distribution: Holarctic

Habitat: forest soils, also arboricolous

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Nomenclatural remark: *Phthiracarus (Archiphthiracarus) globosus* (Koch, 1841) according to Subías (2012)

***Phthiracarus laevigatus* (C.L. Koch, 1841)**

Distribution: Palaearctic: Europe, North Africa, Caucasia, East Asia; St. Helena

Habitat: preferably in dry habitats, in forests, moss, also on wood

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Malaconothridae Berlese, 1916

***Malaconothrus monodactylus* (Michael, 1888)**

Distribution: Holarctic

Habitat: mainly in moist to wet meadow-, bog- and forest-soils

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf); previous studies: 1960–1980 m (moist meadows) (sub. *M. globiger*, regarding synonymy see Weigmann 2006)

Trhypochthoniidae Willmann, 1931

***Trhypochthonius tectorum* (Berlese, 1896)**

Distribution: Holarctic, Oriental and Neotropical region

Habitat: preferably in dry habitats, in moss, rarer in forest soils

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf); previous studies: 1960–1980 m (hay meadow), pine forest at 2050 m (Zirbenwald), 2100–2500 m (alpine meadows with lichen communities, alpine meadows & dwarf shrub community), 2800–3100 m (Androsacetum alpinae)

Remark: In previous investigations this species has been found also at higher altitudes compared to this study. Whether the occurrence of *T. tectorum* is bound to lower altitudes nowadays or has simply not been detected in our samples cannot be clarified without further investigations.

Crotoniidae Thorell, 1876

***Camisia biurus* (C.L. Koch, 1839)**

Distribution: Holarctic

Habitat: preferably in dry meadows and bushland

Obergurgl area: pine forest at 2050 m (Zirbenwald)

***Camisia spinifer* (C.L. Koch, 1835)**

Distribution: Holarctic, Oriental and Neotropical regions

Habitat: coniferous forests, also arboricolous

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf); previous studies: 1960–1980 m (hay meadow), pine forest at 2050 m (Zirbenwald)

***Platynothrus peltifer* (C.L. Koch, 1839)**

Distribution: Holarctic, New Zealand

Habitat: euryoecious, preferably in moister habitats

Obergurgl area: pine forest at 2050 m (Zirbenwald); previous studies: 1960–1980 m (hay meadow), pine forest at 2050 m (Zirbenwald), 2100 m (dwarf shrub community), 2230 m (alpine meadows with lichen communities)

Nomenclatural remark: *Heminothrus (Platynothrus) peltifer* (Koch, 1839) according to Subías (2012)

Hermanniiidae Sellnick, 1928

***Hermannia gibba* (C.L. Koch, 1839)**

Distribution: Holarctic

Habitat: common in forest litter, moss and bogs

Obergurgl area: pine forest at 2050 m (Zirbenwald); previous studies: 1960–1980 m (hay meadow), pine forest at 2050 m (Zirbenwald), 2100 m (dwarf shrub community), 2250 m (alpine meadows with lichen communities)

Damaeidae Berlese, 1896

***Damaeus gracilipes* (Kulczynski, 1902)**

Distribution: Europe, Caucasia, Central Asia

Habitat: in forests and open forests, litter and moss

Obergurgl area: pine forest at 2050 m (Zirbenwald)

***Epidamaeus bituberculatus* (Kulczynski, 1902)**

Distribution: Europe, Caucasia, Central and Eastern Asia

Habitat: forest litter

Obergurgl area: Nardetum at 2300 m (Schönwieskopf)

Nomenclatural remark: *Damaeus (Epidamaeus) bituberculatus* (Kulczynski, 1902) according to Subías (2012)

***Kunstidamaeus diversipilis* (Willmann, 1951)**

Distribution: Austria, Northern Italy—Prov. Bolzano, Trento; Switzerland—Grisons

Habitat: alpine meadows, raw soils

Obergurgl area: Caricetum at 2600 m (Hohe Mut); previous studies: 1960–1980 m (hay meadow), pine forest at 2050 m (Zirbenwald), 2100–2650 m (alpine meadows with lichen communities, alpine meadows & dwarf shrub community), 2800–3100 m (Androsacetum alpinae).

Remark: The known distribution of this species is restricted to subalpine and alpine habitats of the Central and Southern Alps (Schatz & Schuster 2009). It has also been recorded in the adjacent Grisons (Switzerland, Schweizer 1956). Generally *K. diversipilis* prefers alpine dwarf-shrub and grass heathland. In the present study it was found only at 2600 m (Hohe Mut), while in previous studies it was detected at all sampled altitudes in Obergurgl (sub. *Spatiodamaeus diversipilis*).

Nomenclatural remark: *Damaeus (Kunstdamaeus) diversipilis* (Willmann, 1951) according to Subías (2012)

***Metabelba pulverosa* Strenzke, 1953**

Distribution: Europe, Caucasia, Central Asia

Habitat: forest litter, moss, lichen

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Nomenclatural remark: *Metabelba (M.) pulverulenta* (Koch, 1839) according to Subías (2012)

***Porobelba spinosa* (Sellnick, 1920)**

Distribution: Palaearctic

Habitat: preferably in dry forest litter and meadows, moss, lichen

Obergurgl area: pine forest at 2050 m (Zirbenwald); previous studies: 1960–1980 m (hay meadow)

Cepheidae Berlese, 1896

***Cepheus dentatus* (Michael, 1888)**

Distribution: Europe, Caucasia, Eastern Asia

Habitat: forest soils, coniferous litter, also arboricolous

Obergurgl area: pine forest at 2050 m (Zirbenwald)

***Cepheus latus* C.L. Koch, 1835**

Distribution: Holarctic

Habitat: forest soils and moss, also arboricolous

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Eremaeidae Oudemans, 1900

***Eueremaus oblongus* (C.L. Koch, 1835)**

Distribution: Holarctic

Habitat: preferably in dry forest soils, on bark, in moss

Obergurgl area: pine forest at 2050 m (Zirbenwald); previous studies: pine forest at 2050 m (Zirbenwald), 2100–2340 m (alpine meadows with lichen communities), 2650–3100 m (alpine meadows, Androsacetum alpinae)

Caleremaeidae Grandjean, 1965

***Caleremaus monilipes* (Michael, 1882)**

Distribution: Europe, North Africa, Makaronesia, Caucasia

Habitat: forest soils, also arboricolous

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf); previous studies: pine forest at 2050 m (Zirbenwald), 2100–2190 m (dwarf shrub community), 2250–2340 m (alpine meadows with lichen communities), 2500 m (scree slope)

Liacaridae Sellnick, 1928

***Adoristes ovatus* (C.L. Koch, 1839)**

Distribution: Holarctic

Habitat: in forest litter, also mining in conifer needles

Obergurgl area: pine forest at 2050 m (Zirbenwald)

***Liacarus coracinus* (C.L. Koch, 1840)**

Distribution: Holarctic

Habitat: euryoecious, preferably in forest soils and meadows with much organic content

Obergurgl area: pine forest at 2050 m (Zirbenwald); previous studies: 1960–1980 m (hay meadows), pine forest at 2050 m (Zirbenwald), 2100–2190 m (dwarf shrub community), 2250–2340 m (alpine meadows with lichen communities), 2500 m (scree slope)

***Liacarus oribatelloides* Winkler, 1956**

Distribution: Central Europe: Czech Republic, Austria, Southern Germany

Habitat: forest soils

Obergurgl area: pine forest at 2050 m (Zirbenwald); previous studies: pine forest at 2050 m (Zirbenwald)

Peloppiidae Balogh, 1943

***Ceratoppia bipilis* (Hermann, 1804)**

Distribution: Holarctic, Central America

Habitat: preferably in forest soils, also arboricolous

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Carabodidae C.L. Koch, 1837

***Carabodes schatzi* Bernini, 1976**

Distribution: Central and Southern Alps: Austria—North Tyrol, Northern Italy—Prov. Sondrio, Bolzano; Switzerland—Grisons; Caucasia

Habitat: alpine habitats

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf); previous studies: pine forest at 2050 m (Zirbenwald), 2100–2190 m (dwarf shrub community), 2250–2340 m (alpine meadows with lichen communities), 2500 m (scree slope) (sub. *Carabodes minusculus*)

Remark: *Carabodes schatzi* seems to be restricted to the subalpine and alpine zone. This species is expected to have a broader distribution at least in Austria since it was probably confused with *C. minusculus* in the past. *Carabodes schatzi* therefore was classified as sub-endemic for Austria (Schatz & Schuster 2009). Recently this species was also recorded from Caucasia (Shtanchaeva & Subías 2010).

Nomenclatural remark: *Carabodes* (*Klapperiches*) *schatzi* Bernini, 1976 according to Shtanchaeva and Subías (2010) and Subías (2012)

***Carabodes* sp. (Figs 4–6)**

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Remark: This species belongs to the “femoralis” group (see Reeves & Behan-Pelletier 1998). The integument is dark brown. Body size ranges between 490–590 µm. The interlamellar region shows a chevron-shaped elevation, interlamellar setae are 40 µm in length, spiniform and inserted near the base of lamellae. The surface of the prodorsum is covered with minute tubercles, bothridium with small foveae. The dorsosejugal depression is narrow. The notogaster has irregular longitudinal ridges. Notogastral setae are 40 µm long and spiniform, setae c_2 are shorter (20–25 µm). This species shows morphological characteristics of *Carabodes rugosior* Berlese, 1916 and *C. hoh* Reeves & Behan-Pelletier, 1998, but it differs from both species in the length of the interlamellar and

notogastral setae, in sculpturing of prodorsum and in width of the dorsosejugal depression. *Carabodes* sp. was only found in the lowest study site (pine forest, 2050 m) but there it was the fourth most common species in abundance. Recently we found this species also in adjacent regions of the Central Alps (unpubl.).

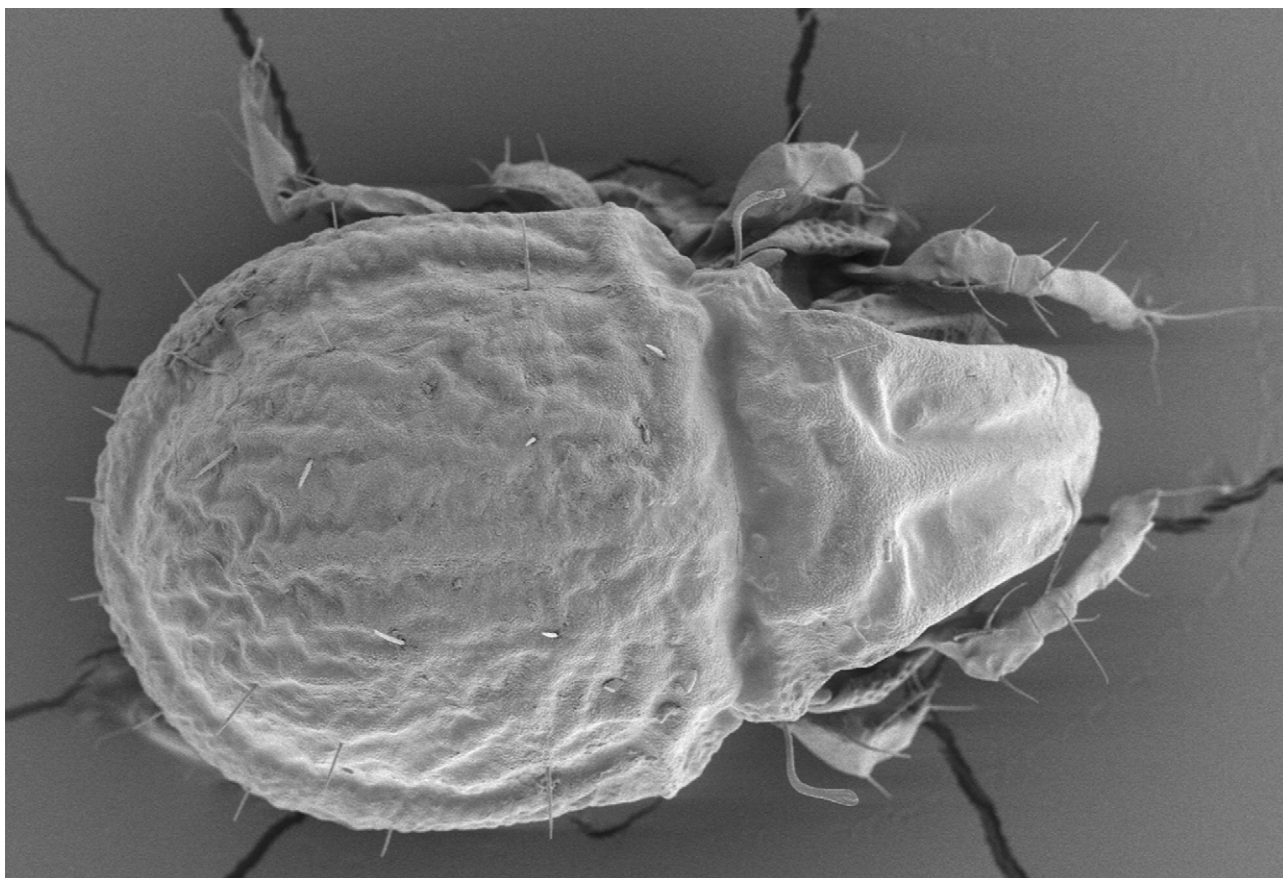


FIGURE 4. *Carabodes* sp. Dorsal aspect.

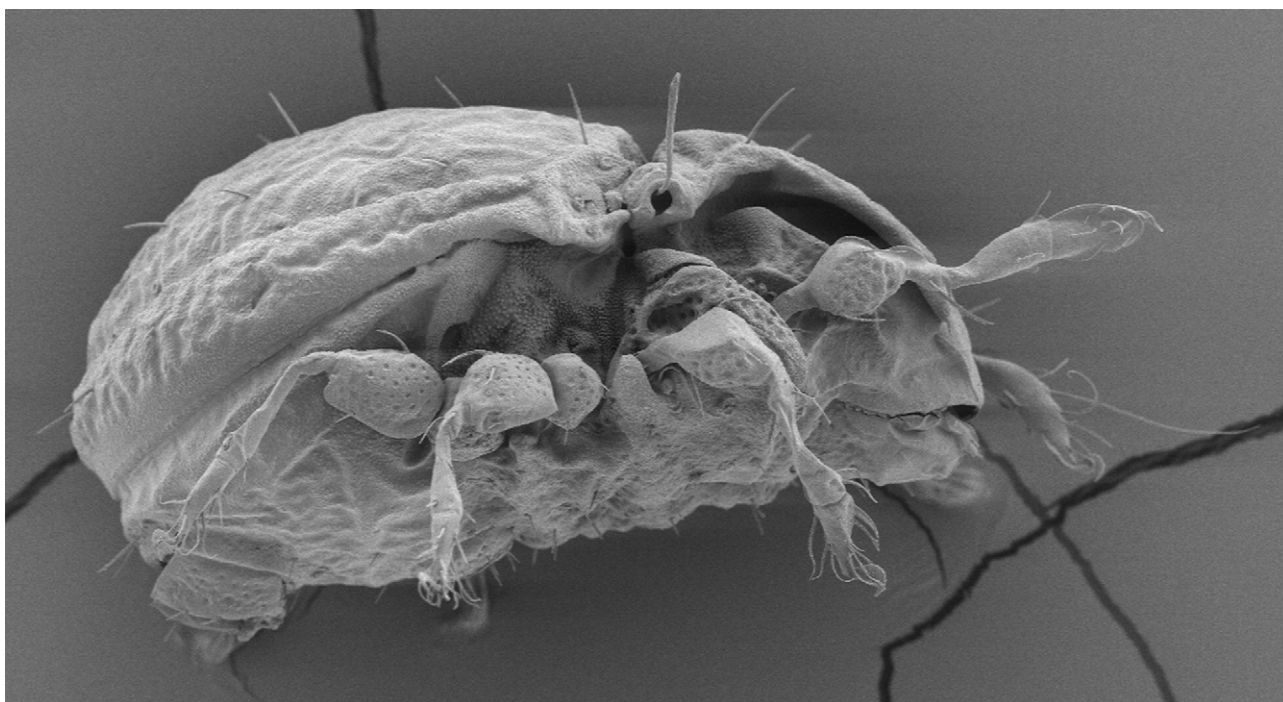


FIGURE 5. *Carabodes* sp. Lateral aspect.

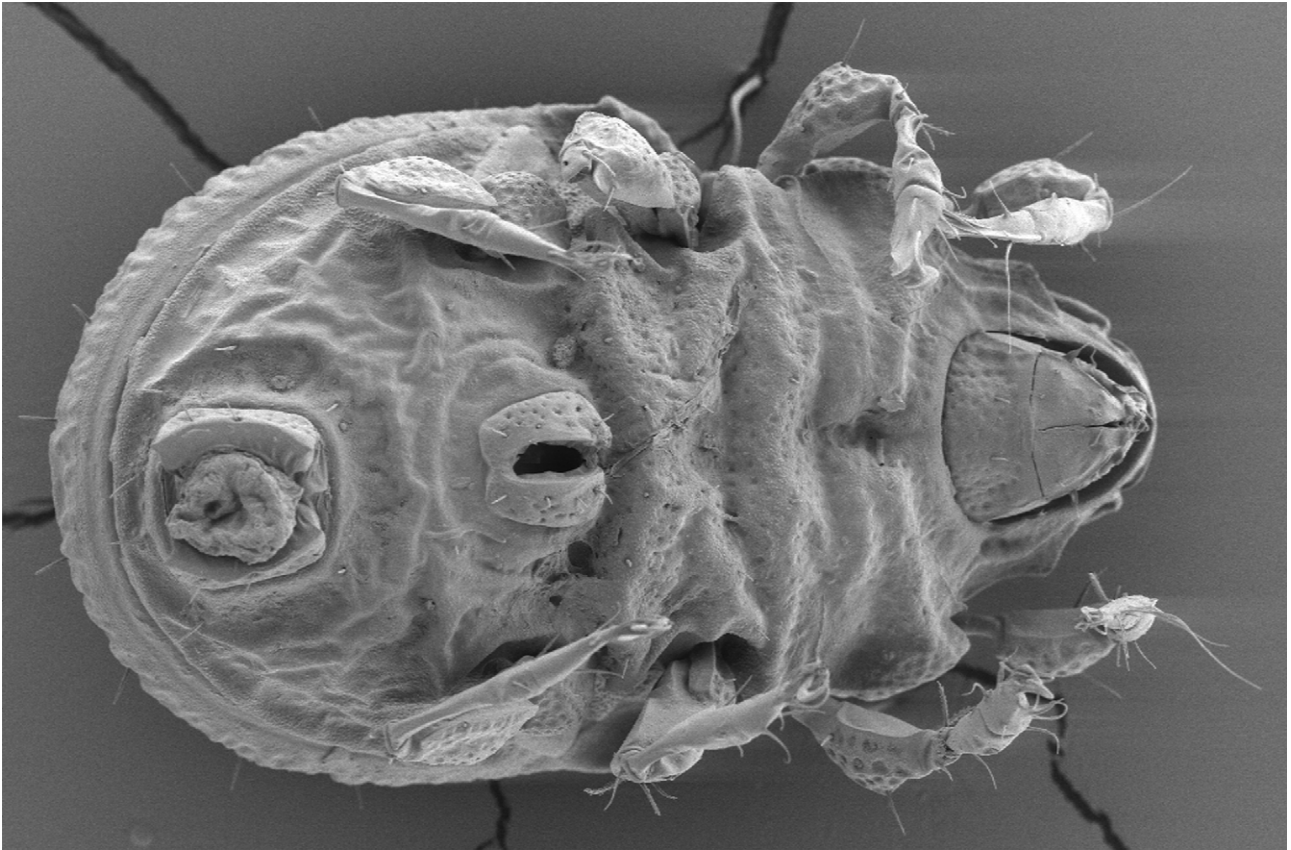


FIGURE 6. *Carabodes* sp. Ventral aspect.

Tectocephidae Grandjean, 1954

***Tectocephus velatus sarekensis* Trägårdh, 1910**

Distribution: semicosmopolitan: Holarctic, Oriental and Ethiopian regions, Central America, Australia and Pacific

Habitat: euryoecious species

Obergurgl area: This species has been recorded in all investigated sites: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf), Caricetum at 2600 m (Hohe Mut), Androsacetum alpinae at 2900 m (Liebener Rippe); previous studies: 1960–1980 m (hay meadows), pine forest at 2050 m (Zirbenwald), 2100–2190 m (dwarf shrub community), 2250–2340 m (alpine meadows with lichen communities), 2500 m (scree slope), 2550–2650 m (alpine meadows), 2800–3100 m (Androsacetum alpinae)

Taxonomic remark: The taxonomic rank and position of “*T. velatus. sarekensis*” is still unclear. *Tectocephus* species are primarily parthenogenetic. Nübel-Reidelbach (1994) lumped together the characters of different and heterogeneous populations, and she postulated all studied populations—except of *T. minor*—as members of one large and polymorphic species, *T. velatus*. Weigmann (2002) studied morphological differences between different populations and distinguished distinct groups, tentatively ranked at subspecific level (also in Weigmann 2006). Based on molecular analyses of nucleotide sequences, Laumann *et al.* (2007) suggested that the different morphotypes of *Tectocephus* evolved in absence of sexual reproduction, and that *T. minor*, *T. velatus* and *T. sarekensis* are best considered as distinct species.

***Tectocephus velatus tenuis* Knülle, 1954**

Distribution: Germany, Czech Republic, European Russia, Central Asia

Habitat: rather dry and sandy dune areas and heath

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf), Caricetum at 2600 m (Hohe Mut)

Remark: See *T. velatus sarekensis*

***Tectocephus velatus velatus* (Michael, 1880)**

Distribution: almost cosmopolitan, including Antarctic and Subantarctic Islands

Habitat: undifferentiated, euryoecious species

Obergurgl area: 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf); previous studies: 2190 m (dwarf shrub community), 2250–2340 m (alpine meadows with lichen communities), 2500 m (scree slope), 2550–2650 m (alpine meadows), 2800–3100 m (Androsacetum alpinae)

Remark: See *T. velatus sarekensis*

***Tectocephus* sp.**

Obergurgl area: Caricetum at 2600 m (Hohe Mut)

Remark: The most evident character of this species is the pointed and long lamellar cusp which protrudes beyond the prodorsum. The space between the lamellar cusps is depressed and typically longitudinally striped. The notogaster shows three pairs of notogastral depressions between the pteromorphs. This species is apparently new to science and has also been found in Northern Italy—Prov. Bolzano (Fischer & Schatz 2007; Schatz 2008); it seems to be restricted to alpine regions. A description is in preparation.

Quadropiidae Balogh, 1983

***Quadropia quadricarinata* (Michael, 1885)**

Distribution: Holarctic, Oriental region, Madagascar

Habitat: forest soils, also arboricolous

Obergurgl area: pine forest at 2050 m (Zirbenwald); previous studies: 1980 m (hay meadow), pine forest at 2050 m (Zirbenwald)

Oppiidae Grandjean, 1951

***Berniniella bicarinata* (Paoli, 1908)**

Distribution: Palaearctic

Habitat: preferably in forest soils

Obergurgl area: pine forest at 2050 m (Zirbenwald)

***Dissorhina ornata* (Oudemans, 1900)**

Distribution: Holarctic

Habitat: preferably in dry forest soils, also in lichens

Obergurgl area: pine forest at 2050 m (Zirbenwald); previous studies: pine forest at 2050 m (Zirbenwald)

***Dissorhina signata* (Schwalbe, 1989)**

Distribution: Northern Italy—Prov. Bolzano, Trento, Sondrio; Germany, Slovakia, Switzerland—Grisons; Romania—Transylvania, Austria

Habitat: montane forest soils?, in moss on tree

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Remark: This species is described from a spruce forest in Germany (Schwalbe 1989). In our study it was only detected in the *Pinus cembra* forest. *Dissorhina signata* was found in several places in Central Europe. This is the first record for Austria and the Central Alps.

***Micropia minus* (Paoli, 1908)**

Distribution: almost cosmopolitan, including Subantarctic Islands

Habitat: undifferentiated, euryoecious species

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Oppiella (Moritzoppia) unicarinata (Paoli, 1908)

Distribution: Holarctic

Habitat: forest soils, in moss

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Oppiella (Rhinoppia) obsoleta (Paoli, 1908)

Distribution: Holarctic, New Zealand

Habitat: euryoecious species

Obergurgl area: pine forest at 2050 m (Zirbenwald); previous studies: 1960 m (hay meadow), pine forest at 2050 m (Zirbenwald), 2100–2190 m (dwarf shrub community), 2230–2340 m (alpine meadows with lichen communities)

Oppiella (Rhinoppia) subpectinata (Oudemans, 1900)

Distribution: Holarctic, Ethiopian region (Senegal)

Habitat: euryoecious species; preferably in soils with high content of organic substances

Obergurgl area: pine forest at 2050 m (Zirbenwald); previous studies: pine forest at 2050 m (Zirbenwald)

Oppiella (Oppiella) falcata (Paoli, 1908)

Distribution: Europe, Caucasia, Central Asia

Habitat: (deciduous) forest soils

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf), Caricetum at 2600 m (Hohe Mut); previous studies: pine forest at 2050 m (Zirbenwald)

Nomenclatural remark: *Lauropia falcata* (Paoli, 1908) according to Subías (2012)

Oppiella (Oppiella) nova (Oudemans, 1902)

Distribution: almost cosmopolitan, including Subantarctic Islands

Habitat: euryoecious species

Obergurgl area: Caricetum at 2600 m (Hohe Mut), Androsacetum alpinae at 2900 m (Liebener Rippe); previous studies: pine forest at 2050 m (Zirbenwald)

Oppiella (Oppiella) obscura (Mahunka & Mahunka-Papp, 2000)

Distribution: Switzerland, Austria

Habitat: unknown

Obergurgl area: Androsacetum alpinae at 2900 m (Liebener Rippe)

Taxonomic remarks: This species has been described recently as *Lauropia obscura* from alpine meadows in Valais and Grisons in Switzerland (Mahunka & Mahunka-Papp 2000). In the present investigation *O. (Oppiella) obscura* was recorded outside Switzerland for the first time. Hitherto this species was only found in alpine regions. A probable synonymy to *Lauropia doris* (Perez-Inigo, 1978) as assumed by Subías (2012) and *Lauropia tenuipectinata* Subías & Rodriguez, 1988 is not clarified (Weigmann 2006).

Oppiella (Oppiella) uliginosa (Willmann, 1919)

Distribution: Central Europe: Northern Italy—Prov. Bolzano; Austria, Germany, Netherlands, Hungary, Slovakia, Poland

Habitat: preferably in forests; also in moss, arboricolous

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Remark: It is very probable that *O. (Oppiella) uliginosa* was confused with the morphologically similar species *O. (Oppiella) nova* in the past.

Nomenclatural remark: *Oppiella nova uliginosa* (Willmann, 1919) according to Subías (2012)

Suctobelbidae Jacot, 1938

Suctobelba altvateri Moritz, 1970

Distribution: Central and Southern Europe, Caucasia

Habitat: preferably in moist forest soils, moss

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Suctobelba regia Moritz, 1970

Distribution: Europe, Central Asia

Habitat: forest soils, in moss

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Remark: This species is a new record to the fauna of Austria; recently it was also found in Carinthia (Schatz unpubl.) and Vorarlberg (Schatz & Fischer 2013).

Suctobelbella acutidens lobata (Strenzke, 1951)

Distribution: Europe, Caucasia

Habitat: preferably moist meadows, in moss

Obergurgl area: 2050 m (Zirbenwald)

Suctobelbella hamata Moritz, 1970

Distribution: Europe, Macaronesia

Habitat: preferably in coniferous forest soils, in moss

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Suctobelbella perforata (Strenzke, 1950)

Distribution: Palaearctic

Habitat: preferably in moist habitats, in forest soils

Obergurgl area: Androsacetum alpinae at 2900 m (Liebener Rippe)

Suctobelbella sarekensis (Forsslund, 1941)

Distribution: Holarctic

Habitat: euryoecious species

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Nomenclatural remark: *Suctobelbella* (*S.*) *acutidens sarekensis* (Forsslund, 1941) according to Subías (2012)

Suctobelbella subcornigera (Forsslund, 1941)

Distribution: Holarctic, Oriental region, New Zealand

Habitat: euryoecious species

Obergurgl area: pine forest at 2050 m (Zirbenwald)

None of the recently recorded species of the family Suctobelbidae was found in this region in previous studies. But it has to be mentioned that two species were reported in Obergurgl in the 1970s (using the available identification keys): *Suctobelba trigona* in 1960–1980 m (hay meadows), pine forest at 2050 m (Zirbenwald), 2100 m (dwarf shrub community), 2230 m (alpine meadows with lichen communities) and *Suctobelbella subtrigona* in 1960–1980 m (hay meadows), pine forest at 2050 m (Zirbenwald), 2100–2190 m (dwarf shrub community), 2250–2340 m (alpine meadows with lichen communities), 2500 m (scree slope), 2800–3100 m (Androsacetum alpinae). Probably modern determination keys lead to the increase of detected species. It is remarkable that almost all Suctobelbidae species were found below the timberline. Only *S. perforata* was detected at 2900 m, but not in the lower study sites. Most probably this is referable to the periodical wetness due to snow melt and the exposure of the rocky promontory of Liebener Rippe.

Thyrisomidae Grandjean, 1953

***Pantelozetes paolii* (Oudemans, 1913)**

Distribution: Holarctic

Habitat: in moist and wet forest soils and meadows

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf); previous studies: 1960–1980 m (hay meadows), pine forest at 2050 m (Zirbenwald), 2100–2190 m (dwarf shrub community), 2250–2340 m (alpine meadows with lichen communities), 2500 m (scree slope), 2550–2650 m (alpine meadows), Androsacetum alpinae at 2800–3100 m (Liebener Rippe) (sub. *Oribella paolii*)

Cymbaeremaeidae Sellnick, 1928

***Cymbaeremaeus cymba* (Nicolet, 1855)**

Distribution: Palaeartic

Habitat: arboricolous: preferably in lichens and dry moss on tree bark, rarely in litter on the ground

Obergurgl area: pine forest at 2050 m (Zirbenwald); previous studies: pine forest at 2050 m (Zirbenwald)

Micreremidae Grandjean, 1954

***Micreremus brevipes* (Michael, 1888)**

Distribution: Palaeartic

Habitat: in xeric habitats, arboricolous: lichens and moss

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Licneremaeidae Grandjean, 1931

***Licneremaeus licnophorus* (Michael, 1882)**

Distribution: Palaeartic

Habitat: in xeric habitats; in moss, also arboricolous

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Passalozetidae Grandjean, 1954

***Passalozetes intermedius* Mihelcic, 1954**

Distribution: Central and Southern Europe, Caucasia, Central and Eastern Asia

Habitat: in xeric habitats; dry meadows

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Remark: In previous studies *Passalozetes perforatus* was detected at 2230 m (alpine meadows with lichen communities) and at 2800–3100 m (Androsacetum alpinae), in the latter in rather high abundances of 300–600 individuals/m². Further investigations must be carried out to reveal if this genus is now restricted to lower altitudes. Nomenclatural remark: *Bipassalozetes (B.) intermedius* (Mihelcic, 1954) according to Subías (2012)

Phenopelopidae Petrunkevich, 1955

***Eupelops curtipilus* (Berlese, 1916)**

Distribution: Europe, Caucasia, Central and Eastern Asia

Habitat: preferably in wet meadows, moss cushions

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf); previous studies: 2190 m (dwarf shrub community), 2250 m (alpine meadows with lichen communities), 2500 m (scree slope)
Nomenclatural remark: *Eupelops sulcatus* (Oudemans, 1914) according to Subías (2012)

***Eupelops plicatus* (C.L. Koch, 1835)**

Distribution: Holarctic

Habitat: preferably in moist soils, in forests, also arboricolous

Obergurgl area: Androsacetum alpinae at 2900 m (Liebener Rippe)

***Eupelops strenzkei* (Knülle, 1954)**

Distribution: Central Europe: Northern Italy, Austria, Germany, Netherlands, Poland, Lithuania

Habitat: in moist to wet meadows

Obergurgl area: Androsacetum alpinae at 2900 m (Liebener Rippe)

Remark: This species seems to be distributed across Central Europe. Originally described from a moist alder forest fen, we only detected it on the rocky promontory of Liebener Rippe (2900 m). This site is occasionally very wet as a result of the snow melt. Coincident with these findings, *E. strenzkei* was collected in Carinthia (Schatz unpubl.) and Vorarlberg (Schatz & Fischer 2013) in various habitats and altitudes. These are the first records of this species for the Austrian fauna.

***Eupelops subuliger* (Berlese, 1916)**

Distribution: Central, Southern and Eastern Europe, Caucasia, Eastern Mediterranean, Central Asia

Habitat: montane and alpine (forest) soils

Obergurgl area: pine forest at 2050 m (Zirbenwald)

***Eupelops torulosus* (C.L. Koch, 1835)**

Distribution: Palaearctic

Habitat: mainly in forest soils, also in moist and peaty substrates

Obergurgl area: Nardetum at 2300 m (Schönwieskopf)

Family Achipteridae Thor, 1929

***Achipteria sellnicki* van der Hammen, 1952**

Distribution: Europe, Caucasia

Habitat: in rather xeric habitats

Obergurgl area: pine forest at 2050 m (Zirbenwald)

***Anachipteria alpina* (Schweizer, 1922)**

Distribution: Northern Italy—Prov. Bolzano, Trento; Austria, Switzerland—Grisons, Valais (above 2250 m a.s.l.); Slovenia (Julian Alps); Bosnia and Herzegovina (above 1000 m a.s.l.); Romania—Carpathian Mountains

Habitat: in moss and lichens, mainly in the alpine and subalpine region

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf); previous studies: 2100–2190 m (dwarf shrub community), 2340 m (alpine meadows with lichen communities), 2500 m (scree slope)

Remark: This species seems to be restricted to montane and alpine habitats.

Nomenclatural remark: *Anachipteria* (*A.*) *shtanchaevae* Subías, 2009 (= *Oribata tecta* var. *alpina* Schweizer, 1922, nom. praeocc. by Halbert, 1915) according to Subías (2012)

***Parachipteria punctata* (Nicolet, 1855)**

Distribution: Holarctic

Habitat: preferably in moist forest soils, in moss, also in moist meadows

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Oribatellidae Jacot, 1925

***Oribatella longispina* Berlese, 1915**

Distribution: Northern Italy—Prov. Sondrio, Belluno, Bolzano, Trento; Austria

Habitat: alpine meadows, in moss, leaf litter

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Remark: This species seems to be restricted to montane and alpine habitats

***Oribatella reticulata* Berlese, 1916**

Distribution: Holarctic: Central, Southern, Eastern Europe, Caucasia, Central Asia, USA: Missouri

Habitat: preferably in xeric habitats, in moss, also arboricolous

Obergurgl area: Androsacetum alpinae at 2900 m (Liebener Rippe)

Ceratozetidae Jacot, 1925

***Ceratozetes thienemanni* Willmann, 1943**

Distribution: Holarctic, Neotropical region

Habitat: forest soils

Obergurgl area: pine forest at 2050 m (Zirbenwald)

***Diapterobates humeralis* (Hermann, 1804)**

Distribution: Holarctic

Habitat: forest soils, in moist meadows, also arboricolous

Obergurgl area: pine forest at 2050 m (Zirbenwald)

***Edwardzetes edwardsi* (Nicolet, 1855)**

Distribution: Europe, Caucasia

Habitat: in forest soils and heathes

Obergurgl area: pine forest at 2050 m (Zirbenwald), Androsacetum alpinae at 2900 m (Liebener Rippe); previous studies: 1960–1980 m (hay meadows), pine forest at 2050 m (Zirbenwald)

Remark: Frequently occurring in alpine habitats. In previous investigations this species was detected only at lower altitudes compared to our recent study—it seems that *E. edwardsi* has expanded its habitat.

***Fuscozetes intermedius* Caroli & Maffia, 1934**

Distribution: Northern Italy—Prov. Bolzano, Trento; Austria, Iberian Peninsula, Western Siberia, Kazakhstan

Habitat: high-montane and alpine meadows and moss cushions

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf), Caricetum at 2600 m (Hohe Mut), Androsacetum alpinae at 2900 m (Liebener Rippe)

Remark: This species seems to be restricted to montane and alpine habitats.

***Fuscozetes setosus* (C.L. Koch, 1839)**

Distribution: Holarctic

Habitat: preferably moist soils, in bogs and forests

Obergurgl area: pine forest at 2050 m (Zirbenwald), Caricetum at 2600 m (Hohe Mut)

***Jugatata angulata* (C.L. Koch, 1840)**

Distribution: Central Europe: Northern Italy—Prov. Bolzano, Trento; Austria, Switzerland—Valais, Basel (canopy), Slovenia, Germany, Czech Republic, Slovakia, Poland

Habitat: frequently arboricolous

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Taxonomic and distributional remarks: See Bayartogtokh and Schatz (2008)

***Jugatala cribelliger* (Berlese, 1904)**

Distribution: Northern Italy—Prov. Bolzano, Trento; Austria, Switzerland—Grisons; Iberian Peninsula

Habitat: unknown

Obergurgl area: Androsacetum alpinae at 2900 m (Liebener Rippe)

Taxonomic and distributional remarks: See Bayartogtokh and Schatz (2008)

***Melanozetes meridianus* Sellnick, 1929**

Distribution: Holarctic

Habitat: alpine grassland, bogs, wet mosses, forest litter

Obergurgl area: Nardetum at 2300 m (Schönwieskopf), Androsacetum alpinae at 2900 m (Liebener Rippe); previous studies: 1960–1980 m (hay meadows), pine forest at 2050 m (Zirbenwald), 2100–2190 m (dwarf shrub community), 2250 m (alpine meadows with lichen communities), 2500 m (scree slope), 2650 m (alpine meadow), 2800–3100 m (Androsacetum alpinae)

***Oromurcia sudetica* Willmann, 1939**

Distribution: Central and Southeastern Europe, Caucasia

Habitat: high montane and alpine meadows, in moss, frequently in moist to wet habitats

Obergurgl area: Caricetum at 2600 m (Hohe Mut), Androsacetum alpinae at 2900 m (Liebener Rippe); previous studies: 1960–1980 m (hay meadows), pine forest at 2050 m (Zirbenwald)

Remark: In the present investigation this species has been found only above the timberline. It is the second most common species of Liebener Rippe representing more than 21% of the oribatid mite community. In earlier investigations in Obergurgl *O. sudetica* occurred solely in meadows on the edge of the timberline reaching high abundances with more than 2400 individuals per m² representing more than 10% of the community (Schatz 1978, 1979). It is an extraordinary finding that this species obviously migrated from comparatively low altitudes to the high alpine zone and seems to have established a stable population. In 2001 *O. sudetica* was recorded in the Rotmoos valley (Schatz unpubl.).

***Trichoribates scilierenensis* Bayartogtokh & Schatz, 2008**

Distribution: North Tyrol, East Tyrol, Vorarlberg (Austria); Northern Italy—Prov. Bolzano, Trento

Habitat: unknown, hitherto only found in alpine meadows.

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf), Caricetum at 2600 m (Hohe Mut), Androsacetum alpinae at 2900 m (Liebener Rippe)

Remarks: *Trichoribates scilierenensis* has been recorded at high altitudes of the Central Alps and Southern Alps and therefore seems to be alpine-endemic (Bayartogtokh & Schatz 2008). Remark: This species seems to be restricted to high altitudes of the Central and Southern Alps. In earlier investigations in Obergurgl this species has also been recorded as “*Trichoribates trimaculatus*” (Schatz 1978, 1979).

***Trichoribates trimaculatus* (C.L. Koch, 1835)**

Distribution: Holarctic

Habitat: meadows, dry moss cushions

Obergurgl area: pine forest at 2050 m (Zirbenwald), Androsacetum alpinae at 2900 m (Liebener Rippe); previous studies: pine forest at 2050 m (Zirbenwald), 2100–2190 m (dwarf shrub community), 2230–2340 m (alpine meadows with lichen communities), 2500 m (scree slope), 2650 m (alpine meadow), 2800–3100 m (Androsacetum alpinae)

Remark: Part of the material from the previous investigations belongs to *T. scilierenensis* (see above).

Nomenclatural remark: Validity of name see Weigmann and Norton (2009)

Chamobatidae Grandjean, 1954

***Chamobates birulai* (Kulczynski, 1902)**

Distribution: Europe, Northern and Central Asia, Greenland

Habitat: forest soils

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Taxonomic remark: The synonymy with *Chamobates tricuspoidatus* Willmann, 1953 as assumed by Weigmann (2006) and Subías (2012) is questionable.

***Chamobates borealis* (Trägårdh, 1902)**

Distribution: Palaearctic

Habitat: forest soils, in moss

Obergurgl area: pine forest at 2050 m (Zirbenwald), Caricetum at 2600 m (Hohe Mut)

Nomenclatural remark: A synonym of *Chamobates (C.) pusillus* (Berlese, 1895) according to Subías (2012)

***Chamobates cuspidatus* (Michael, 1884)**

Distribution: Holarctic, Madagascar

Habitat: in moist forest soils

Obergurgl area: pine forest at 2050 m (Zirbenwald); previous studies: 1980 m (hay meadow), pine forest at 2050 m (Zirbenwald), 2100–2190 m (dwarf shrub community), 2230–2340 m (alpine meadows with lichen communities), 2500 m (scree slope), 2650 m (alpine meadow)

***Chamobates voigtsi* (Oudemans, 1902)**

Distribution: Europe, Caucasia, Central Asia

Habitat: forest soils, in moss

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Nomenclatural remark: *Chamobates (Xiphobates) voigtsi* (Oudemans, 1902) according to Subías (2012)

Mycobatidae Grandjean 1954

***Mycobates* sp. (Figs 7–9)**

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf), Caricetum at 2600 m (Hohe Mut)

Remarks: The body size ranges between 410–500 µm. The lamellar cusps are small, lateral and medial dens are equal in length, hardly visible in light microscope. 10 pairs of notogastral setae, 47 µm long (40–50 µm) and smooth. Porose areas mostly weakly defined and almost impossible to recognise. Tubercular structures along hinge of pteromorph.

This species is similar to *M. carli* Schweizer, 1922, but it differs from the illustration given in Weigmann (2006), a.o. by its extremely small cusps. It was compared with the specimen defined as the holotype of *M. carli* deposited in the collection of Josef Schweizer at the Natural History Museum in Basel (Switzerland) by one of us [BMF]. Unfortunately the holotype is too squashed to support any conclusion. In addition to our analysis we re-examined specimens collected from previous investigations in the same area (Obergurgl/ Rosskar, 2650 m, Schatz 1979). These specimens were determined as “*Lepidozetes singularis*”, but they are identical with the *Mycobates* species we found in this study. In the meantime we found this species also in other regions of the Alps (Schatz & Fischer 2013 and unpubl.).

Scheloribatidae Grandjean, 1933

***Scheloribates laevigatus* (C.L. Koch, 1835)**

Distribution: Holarctic, Ethiopian region

Habitat: preferably in moist to wet meadows, also in forest soils

Obergurgl area: pine forest at 2050 m (Zirbenwald), Androsacetum alpinae at 2900 m (Liebener Rippe); previous studies: 1960–1980 m (hay meadows), 2800–3100 m (Androsacetum alpinae)

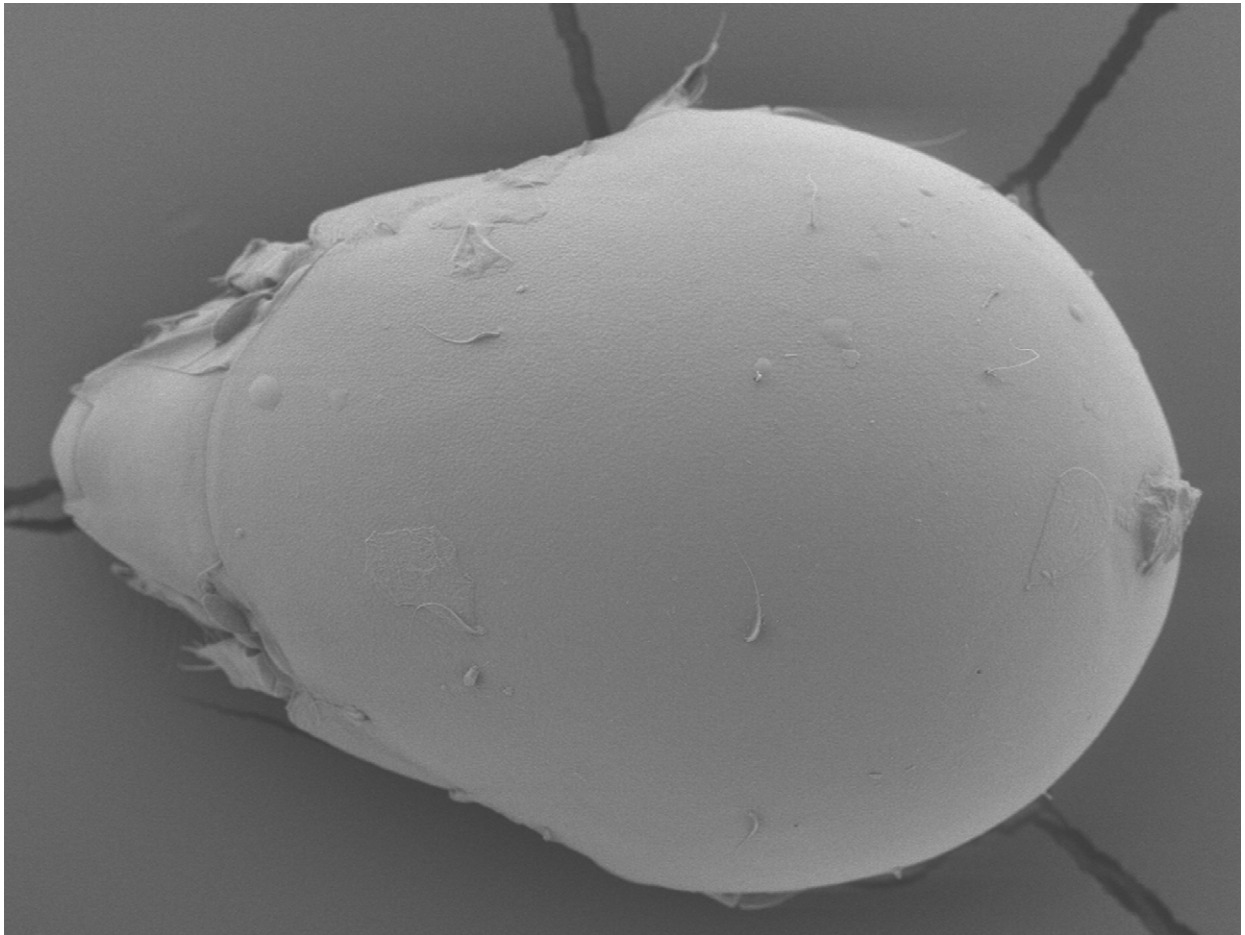


FIGURE 7. *Mycobates* sp. Dorsal aspect.

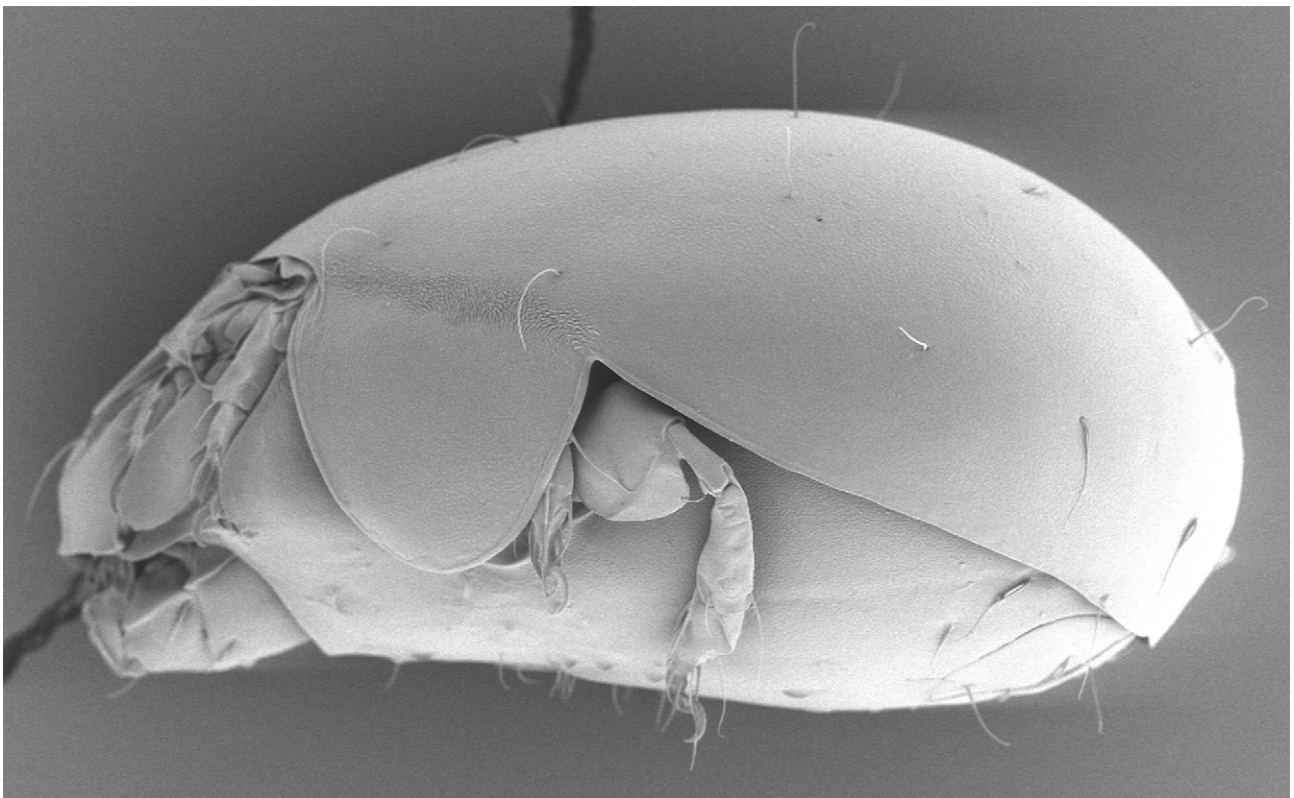


FIGURE 8. *Mycobates* sp. Lateral aspect.

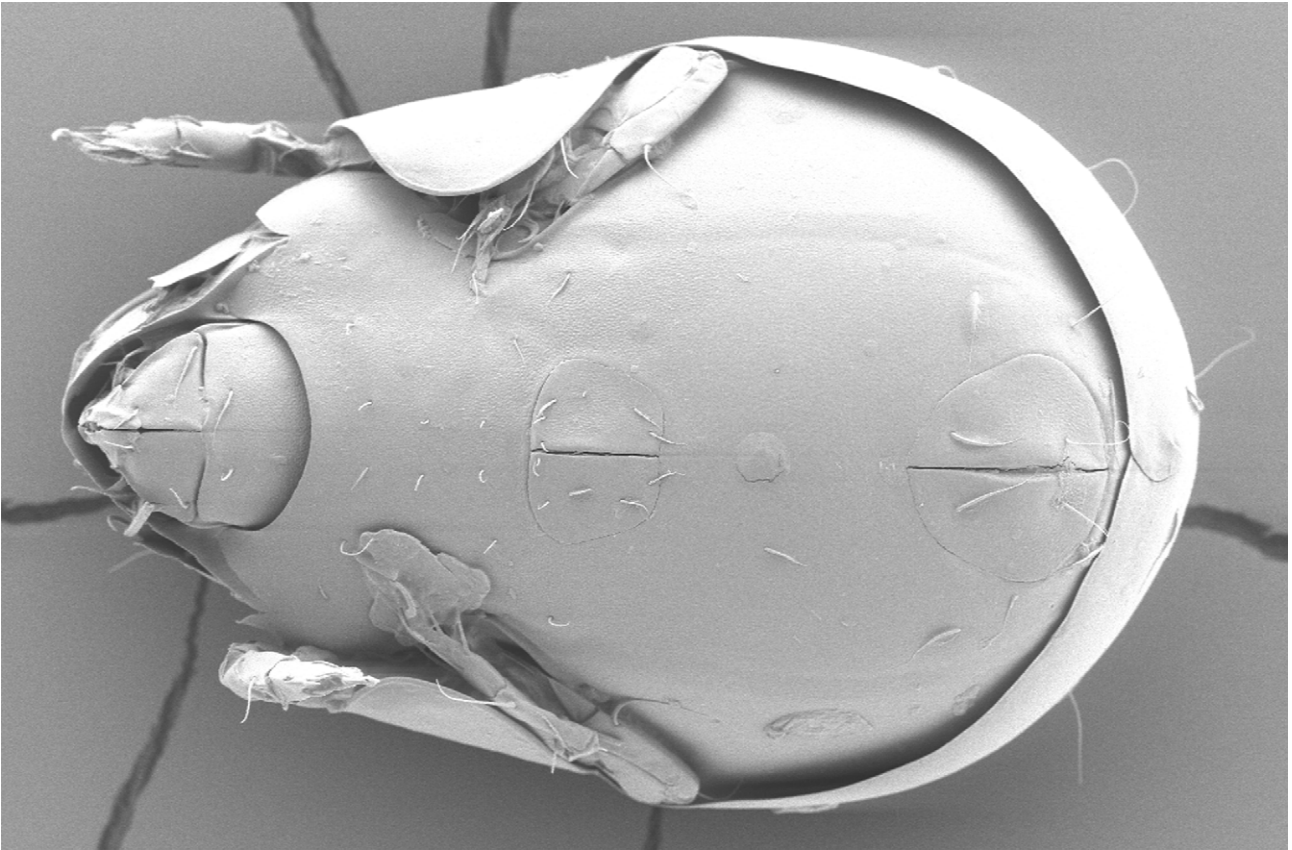


FIGURE 9. *Mycobates* sp. Ventral aspect.

Oribatulidae Thor, 1929

***Oribatula amblyptera* Berlese, 1916**

Distribution: Northern Italy—Prov. Bergamo, Bolzano, Trento; Switzerland, Austria, Eastern Europe (Romania—Transylvania)

Habitat: unknown; preferably in xeric habitats (?)

Obergurgl area: pine forest at 2050 m (Zirbenwald)

Taxonomic remark: A synonym of *Oribatula (O.) tibialis tibialis* (Nicolet, 1855) according to Subías (2012); The morphological differences between the two species as given in Weigmann (2006) are clearly distinguishable in the present material.

***Oribatula interrupta* (Willmann, 1939)**

Distribution: Europe, Mongolia

Habitat: in moss and lichen at alpine and subalpine regions

Obergurgl area: pine forest at 2050 m (Zirbenwald), Caricetum at 2600 m (Hohe Mut)

***Oribatula longelamellata* Schweizer, 1956**

Distribution: Central and Southeast Europe: Northern Italy—Prov. Bolzano; Switzerland: Grisons; Poland, Germany, Romania (Southern Carpathian mountains)

Habitat: moss and shrubs

Remarks: This species was described from Grisons, Switzerland and has been reported from other mountainous regions in Central and Southeastern Europe. We recently recorded it in Northern Italy—Prov. Bolzano at the Resia Pass (Fischer & Schatz 2009) and in Pfeders Valley (Schatz & Fischer 2011) south of our investigation site, as well as in Vorarlberg, Austria (Schatz & Fischer 2013). All our findings of *O. longelamellata* were in the subalpine and

alpine zone. In this study we found this species at all four altitudes. In the alpine meadows of Hohe Mut (2600 m) it is the second most common oribatid mite species and represents a quarter of all oribatid mite species in this habitat.

***Oribatula tibialis* (Nicolet, 1855)**

Distribution: Holarctic

Habitat: in meadows, forests, moss and lichens, also arboricolous

Obergurgl area: pine forest at 2050 m (Zirbenwald), Nardetum at 2300 m (Schönwieskopf), Caricetum at 2600 m (Hohe Mut), Androsacetum alpinae at 2900 m (Liebener Rippe); previous studies: 1960–1980 m (meadows), pine forest at 2050 m (Zirbenwald), 2100–2190 m (dwarf shrub community), 2250–2340 m (alpine meadows with lichen communities), 2500 m (scree slope), 2550–2650 m (alpine meadows), 2800–3100 m (Androsacetum alpinae)

Nomenclatural remark: *Oribatula (O.) tibialis tibialis* (Nicolet, 1855) according to Subías (2012); see also remark at *O. amblyptera*

***Phauloppia nemoralis* (Berlese, 1916)**

Distribution: Europe

Habitat: preferably in xeric habitats, in lichens and moss, forest soils

Obergurgl area: pine forest at 2050 m (Zirbenwald)

General considerations

Compared with the previous investigation in the area (Schatz 1978, 1979), the species composition of oribatid mites seems to shift over the years notably. Though this might partly be caused by taxonomical and systematical changes and corrections, we detected displacements in the four most abundant species when comparing studies carried out in the 1970s and 2010 (Tab.2). In the pine forest, the number of recorded species increased from 54 (1979) to 73 (2010). The formerly most abundant species *T. velatus sarekensis* is now, 30 years later, only at place 29. For a long time *O. (Oppiella) uliginosa* has been considered as synonym of *O. (Oppiella) nova*, it was redescribed by Woas (1986), which lead to a broad acceptance of the validity of this species. Therefore, it is most likely that specimens identified as *O. (Oppiella) nova* found in the 1970s in fact partly or totally belong to *O. (Oppiella) uliginosa*.

The most remarkable changes are noted in Androsacetum alpinae at Liebener Rippe: little more than half species detected in 1970s (30 spp.) could be found in 2010 (16 spp.). In none of our samples *T. velatus velatus* was caught, instead *T. velatus sarekensis* was quite abundant with nearly 340 individuals per m², which corresponds with the 8th most abundant oribatid mite of this community. The unexpected occurrence of *O. sudetica* and *E. edwardsi* on Liebener Rippe is discussed above. It is remarkable that species with very different ecological requirements coexist in this habitat, i.e. species that are adapted to xeric and rather dry habitats (e.g. *O. reticulata*, *T. trimaculatus*), as well as species which prefer wet to moist habitats (e.g. *O. sudetica*, *S. perforata*) and euryoecious species (e.g. *T. velatus sarekensis*, *O. (Oppiella) nova*). This could be caused by the presence of different microhabitats due to periodically wet conditions in contrast to periods of sun-exposure.

The second most common oribatid mite in Androsacetum alpinae at Liebener Rippe in the 1970s was *Zygoribatula exilis*. Thirty years later we did not find even a representative of the genus *Zygoribatula* in the soil samples of our study area. *Jugatala cribelliger*, the fourth most common oribatid mite seems to be new to the area, since it was not detected in the 1970s. A remarkable shift is apparent especially at the highest altitude when group spectra of oribatid mite communities in previous studies are compared with recent investigations (Fig.10). Recently Poronota and pycnonotic Apherederemata (mainly represented by *T. velatus sarekensis*) were found on Liebener Rippe. That follows the findings of Maraun & Scheu (2000) which stated that Poronota and *Tectocephus* dominate in sites where total oribatid mite density is low. Forty years ago the group spectrum was more divers with Poronota, pycnonotic Apherederemata, Enarthronota, Desmonomata and Eupherederemata, each of these groups represented by at least three species. Enarthronota are known to be very sensitive to (mechanical) disturbances, probably they are also a suitable group to detect other changes in a certain habitat.

TABLE 2. Four dominating species in Zirbenwald (pine forest, 2050 m a.s.l.) and Liebener Rippe (Androsacetum alpinae, 2900 m a.s.l.) in 1979 and 2009.

	1979	2009
Zirbenwald	<i>Tectocepheus sarekensis</i> <i>Dissorhina ornata</i> <i>Oppiella nova</i> <i>Caleremaeus monilipes</i>	<i>Oppiella (Oppiella) uliginosa</i> <i>Dissorhina ornata</i> <i>Chamobates cuspidatus</i> <i>Carabodes cf. rugosior</i>
Liebener Rippe	<i>Tectocepheus velatus</i> <i>Zygoribatula exilis</i> <i>Fuscozetes fuscipes</i> <i>Melanozetes meridianus</i>	<i>Melanozetes meridianus</i> <i>Oromurcia sudetica</i> <i>Fuscozetes intermedius</i> <i>Jugatala cribelliger</i>

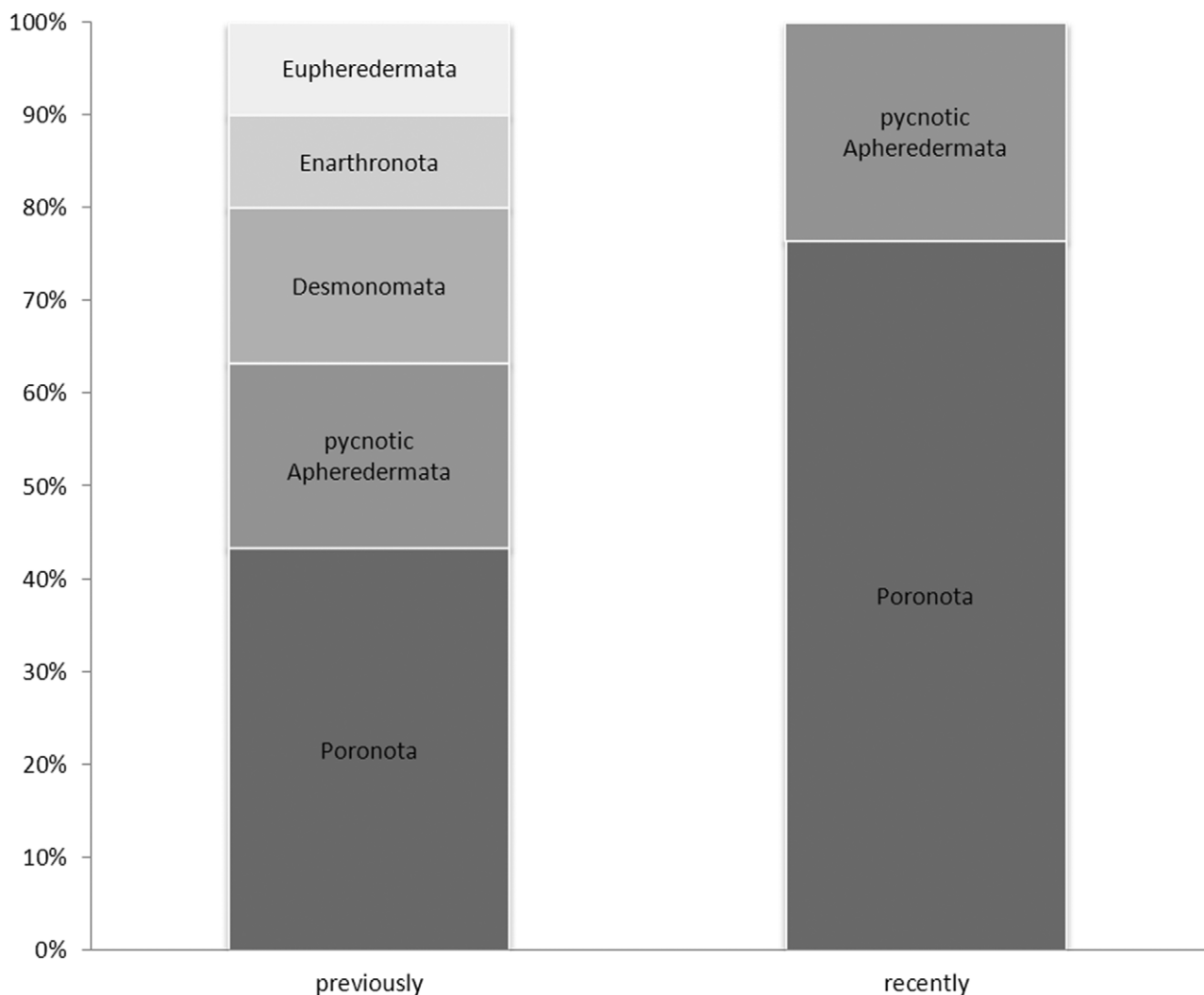


FIGURE 10. Group spectra of the oribatid mite community on Liebener Rippe, Androsacetum alpinae, 2900 m a.s.l. in previous and recent investigations.

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