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Faunistics of oribatid mites (Acari, Oribatida) in dry grassland sites in the Eisack Valley (South Tyrol, Prov. Bolzano, Italy)

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Abstract

Oribatid mites were investigated in five dry grassland sites in the basin around Klausen / Chiusa (South Tyrol). Soil and litter samples were taken from characteristic microhabitats (dry grassland, dry bushland, rocky steppe). A total of 150 oribatid species belonging to 47 families were encountered, most of them closely associated with dry habitats. *Gymnodamaeus irregularis* Bayartogtokh & Schatz, 2009 and *Liochthonius perelegans* Moritz, 1976 are new records for Italy, additional six species are new records for South Tyrol. Two species (*Licneremaeus* sp., *Pseudoppia* sp.) could not be identified at species level, possibly they are undescribed species. Remarkable species are presented, and their general distribution and habitat requirements pointed out. The possible origin of the oribatid mite species in dry grasslands is discussed, as inferred from the high proportion of 'mediterranean species' with distribution centre in South or Southeast Europe. The species assemblages of the different sites and habitats are compared.

Keywords Alps | species assemblages | distribution | ecology

1. Introduction

Dry grasslands are unfertilized plant communities in arid locations. Secondary dry grasslands were formed from dry forests by clearing and are remnants of ancient cultural landscapes. In Central Europe they belong to the most threatened habitats (Holzner 1986). Previous investigations of oribatid mites in dry grasslands in the Central Alps (e.g. Schatz 1996: Virgental, East Tyrol, Schatz & Fischer 2015: western North Tyrol, Perlinger & Schatz 2009: Carinthia, Lazarus & Krisper 2014: Styria) demonstrated the presence of a surprisingly high diversity within this taxon and the presence of specialised xerophilous species, which do not occur in the surrounding habitats. Among those are several so called 'southern' or 'mediterranean' species with distribution centre in South or Southeast Europe or in the southern Palaearctic region (Schuster 1959, 1960, Tarman 1977, Höpperger & Schatz 2013).

The Eisack valley / Valle Isarco around Klausen / Chiusa is favoured by a warm climate and some well-preserved dry grasslands still exist in this area. In the course of the 'day of biodiversity' event in South Tyrol in 2017, soil and litter samples were taken on the hill of the monastery Säben / Sabiona near Klausen / Chiusa. The high species richness of the oribatid mite community led to further sampling in surrounding dry grasslands. The present study on oribatid mites aims at a faunistic overview of an endangered habitat and adds new data to faunistic and ecological investigations on oribatid mites in South Tyrol (cf. Schatz 2018).

2. Investigation area and methods

The basin of Klausen / Chiusa is situated in the centre of the Eisack valley north of Bozen / Bolzano. Five sites

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in a linear distance of up to 4 km from Klausen with dry grasslands were chosen (Fig. 1), three of them protected as nature reserve or natural monument. A total of 40 soil and litter samples were taken in different sites and habitats (the number of samples taken in each habitat is given in brackets).

Säben, hill of monastery Säben / Sabiona (municipality Klausen / Chiusa): by far the largest site: Submediterranean shrub forest with *Quercus pubescens*, *Ostrya carpinofolia*, *Fraxinus ornus*, leaf litter, patches of moss in moist crevices (6 samples), dry grassland (6) and rocky steppe (2) on a small hill. (46°38′N, 11°34′E, 570–710 m a.s.l., 24.vi.2017, 23.viii.2017)

Trumbichl, natural monument (municipality Feldthurns / Velturno): Rocky steppe with lichens and *Sempervivum arachnoideum* (3 samples), dry grassland with *Thymus* (2), leaf litter of shrub forest with *Quercus pubescens* (1) (see also Hilpold et al. 2017). (46°39'N, 11°36′E, ca. 880 m a.s.l. , 25.v.2018)

Raffeil, hill near Gufidaun / Gudon, nature monument (municipality Klausen / Chiusa): Dry grassland with grass and herbs (3 samples), rocky steppe with lichens, moss, *Sempervivum arachnoideum* (4), leaf litter of shrub forest with *Quercus pubescens*, *Fraxinus ornus* (3). (46°38′N, 11°35′E, 720–740 ma.s.l. , 25.v.2018)

Teis, a sun-exposed ridge above the village Teis / Tiso (municipality Villnöss / Funes) with dry grassland, shrubs and rocky steppe surrounded by pine forest: Dry grassland with herbs (3 samples), rocky steppe with moss and *Sempervivum arachnoideum* (1), litter under shrubs *Juniperus communis*, *Ligustrum vulgare* (2). (46°39'N, 11°37'E, 1000–1020 m a.s.l. , 25.v.2018)

Lajen, biotope Wasserbühl (municipality Lajen / Laion): The extent of dry habitats at this site is very small and consists mainly of a rocky crest with moss and herbs, surrounded by moister meadows and bushland. This site shows less extreme dry conditions than the other sites. Samples were taken on slab of rock with moss (3 samples) and dry grassland with herbs (1). (46°36'N, 11°33'E, 1100 m a.s.l., 25.v.2018).

The oribatid mites were collected by cutting out about 10 × 10 cm pieces of soil with grass or herbs, or

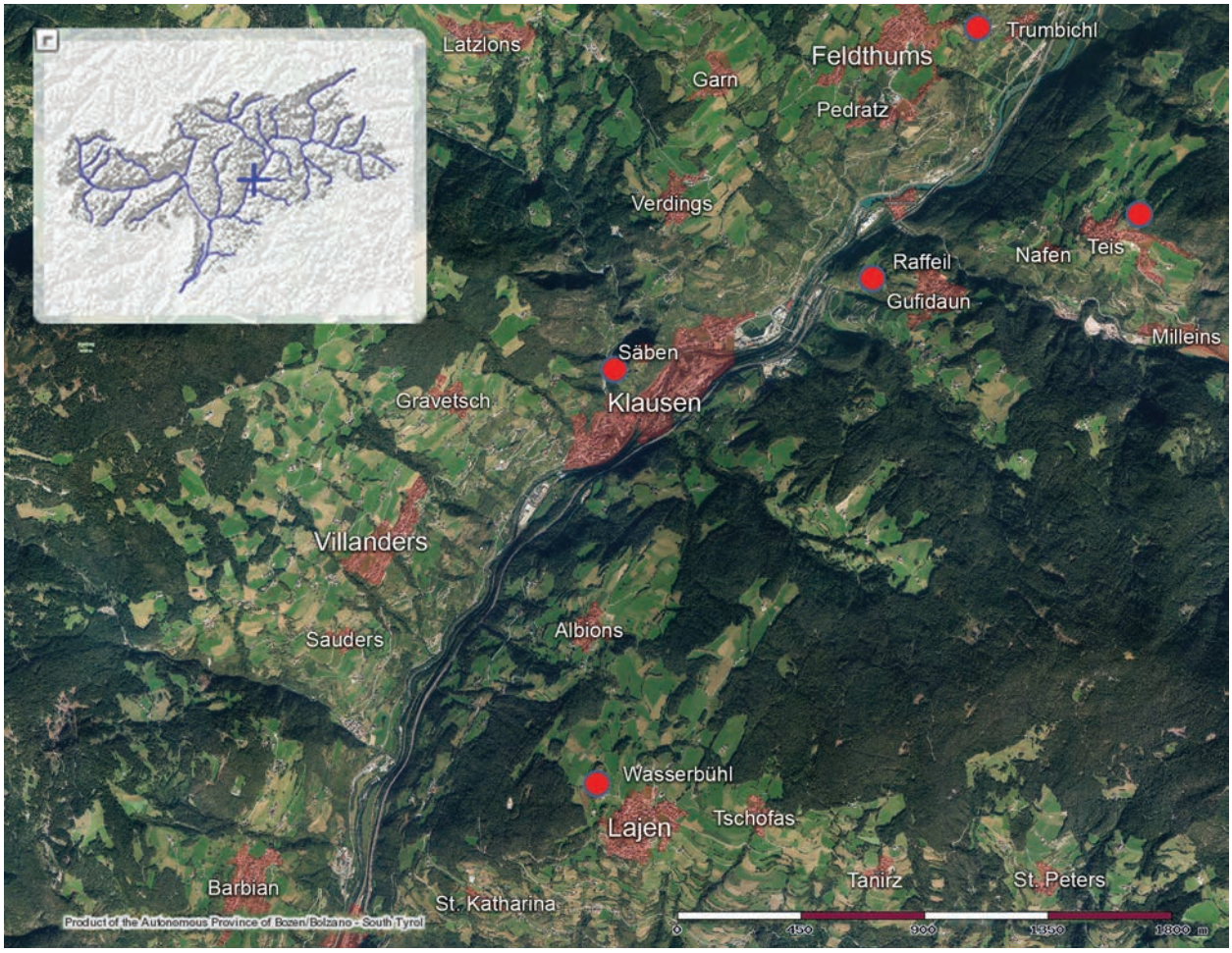

Figure 1. Oribatid mites in dry grasslands in the Eisack Valley / Valle Isarco (South Tyrol). Circles give the location of the five sites of the present investigation. [http://gis2.provinz.bz.it/geobrowser/?project=geobrowser_pro&view=geobrowser_pro_atlas-b&locale=de]

by taking ca. ½ liter of partially decayed leaf litter or moss cushions under bushes and trees, or by scratching moss and lichens from rocks. The extraction of the material was carried out using a Macfadyen extractor in the Institute of Ecology, University of Innsbruck (extraction time 9 days). The species determination of the oribatid mites followed mainly the key of Weigmann (2006). For some taxa special descriptions, literature and compilations were used (e.g. Pérez-Íñigo 1993, 1997, Subías & Arillo 2001, Subías et al. 2018). Juveniles were determined as far as possible. Due to the purpose of this study as a faunistic overview sampling was not aimed at quantitative analyses and abundances were estimated only roughly. The species similarity was calculated using the Sørensen-Index (Mühlenberg 1993, Southwood & Henderson 2000):

$s = 2n(t) / (n(a) + n(b))$, where n(t) is the number of species present in both habitats A and B, n(a) the number of species present in habitat A, and n(b) the number of species present in habitat B.

This allows a simple comparison of species assemblages from non-uniform samples without quantitative aspects (as abundance or dominance). Faunistic relationships become obvious with higher species similarity.

3. Results and Discussion

A total of 150 species belonging to 47 families were encountered (Tab. 1). Families richest in species are Oppiidae (14 spp.), Scheloribatidae, Suctobelbidae (9 spp. each), Oribatulidae (8 spp.), Galumnidae (7 spp.), Crotoniidae, Gymnodamaeidae (6 spp. each), Brachychthoniidae, Ceratozetidae, Chamobatidae, Liacaridae (5 spp. each). Thus, more than half of all species belong to one of these eleven families. Most frequent species are *Tectocepheus sarekensis* (in 25 of 40 samples), *Peloptulus phaeonotus* (20 samples), *Eueremaeus valkanovi* (18), *Oribatula caliptera*, *Zygoribatula glabra* (15 samples each), *Licnodamaeus pulcherrimus* (14), *Passalozetes africanus* (13). On the other hand 42 species were found as single records only (with 1, 2 or 3 specimens), which suggests the presence of further unrecorded species.

3.1 General distribution

The majority of the oribatid species encountered during this project are already known from South Tyrol (Schatz 2018). *Gymnodamaeus irregularis* and *Liochthonius perelegans* represent new records for Italy, further six species are new records for South Tyrol (*Carabodes minusculus* (sensu Bernini 1976), *Cosmochthonius reticulatus*, *Eupelops claviger*, *Machuella draconis*, *Metabelba parapulverosa*, *Phyllozetes emmae*). Two species (*Licneremaeus* sp., *Pseudoppia* sp.) could not be identified at species level, possibly they are undescribed species.

Most species have a wide general distribution; Central and South Europe (9 spp.), Europe (5 spp.), Palaearctic (45 spp.), Holarctic (43 spp.) and larger ('semi/cosmopolitan', 43 spp.). Five species are only known from the Central and Southern Alps (*Gymnodamaeus irregularis, G. meyeri*, *Licneremaeus* sp., *Pseudoppia* sp., *Xenillus athesis*). The relatively high percentage of 'mediterranean' or 'southern' species in all sites is remarkable (in total 46 spp. or more than 30 %, highest in the habitat dry grassland: 38 %, see Tab. 2). This indicates the importance of the south-to-north oriented valleys in South Tyrol with dry and sunny subtropical climate as dispersal route for mediterranean species towards north, up to the dry grasslands and forests of the Inn valley in North Tyrol (Mihelčič 1962, Schatz & Fischer 2015).

3.2 Habitat preferences

Habitat preferences and special ecological requirements are well documented for many oribatid mite species (summarized in Schatz 1983, Pérez-Íñigo 1993, 1997, Subías & Arillo 2001, Weigmann 2006, Weigmann et al. 2015, and additional unpublished records). Most species show preferences for more than one habitat type. Hence, they may appear in several different categories in the following analysis (Tab. 2). Xerophilous species (in total 79 spp.) account for more than 50 % in most sites and habitats. Their percentage is lowest in the shrub forests (44 %) where silvicolous and euryoecious species are more frequent than in other sites as can be expected. Species with moister habitat requirements are sparsely represented. Most of them occur in the shrub forest of Säben (11 %) with small crevices and water rivulets with moss (52 % of the species in Säben are known to be muscicolous). In other sites only occasional single specimens of hygrophilous species were found, probably scattered from moister surrounding habitats. Lazarus & Krisper (2014) found a proportion of only 23 % xerophilous species in their investigated dry sites. The lower percentage can be explained by the neighbouring forest sites of the study areas. The eight dry sites in Carinthia (Perlinger & Schatz 2009) consist 31 % xerophilous species in total, in different graduation from 47 % down to 12 % in the particular sites, depending from size, the environmental habitats, and mosaic structure of the sites.

Table 1. Oribatid mites in dry grasslands in the Eisack Valley / Valle Isarco (South Tyrol). Species list for each site and for the habitats dry bushland, dry grassland, rocky steppe; general distribution and habitat requirement.

Abbreviations: General distribution cos semi/cosmopolitan, eur Europe, hol Holarctic, c-eur Central Europe, c-n-eur Central-, North Europe, c-s-eur Central-, South Europe, pal Palaearctic, w-pal western Palaearctic, (med) "mediterranean species". Habitat requirement eu euryoecious, hy hygrophilous, li lichenicolous, mu muscicolous, si silvicolous, xe xerophilous. Regarding the terms „xerophilous", „mediterranean – southern species" see text.

	Site					Habitat				
	Säben	Trumbichl	Raffeil	Teis	Lajen	dry bushland	dry grassland	rocky steppe	General distribution	Habitat requirement
samples →	14	6	10	6	4	12	15	13		
Taxon *number of species →*	103	43	56	71	32	110	81	56		
Fam. Achipteriidae										
Parachipteria fanzagoi Jacot, 1929	x					x			hol	si hy
Parachipteria punctata (Nicolet, 1855)	x					x			hol	si hy
Fam. Astegistidae										
Cultroribula lata Aoki, 1961			x			x		x	pal	si xe
Fam. Brachychthoniidae										
Brachychthonius pius Moritz, 1976			x	x		x	x		hol (med?)	si xe
Liochthonius lapponicus (Trägårdh, 1910)	x			x	x	x	x	x	hol	eu
Liochthonius perelegans Moritz, 1976			x	x			x		eur	si xe
Sellnickochthonius immaculatus (Forsslund, 1942)		x	x			x	x		hol - cos	eu
Sellnickochthonius rostratus (Jacot, 1936)				x			x		hol	eu
Fam. Caleremaeidae										
Caleremaeus monilipes (Michael, 1882)	x					x	x	x	eur	si xe
Fam. Carabodidae										
Carabodes labyrinthicus (Michael, 1879)	x		x	x		x	x	x	hol	eu
Carabodes minusculus Berlese, 1923	x			x	x		x	x	pal	xe
Odontocepheus elongatus (Michael, 1879)	x		x		x	x		x	hol	si xe mu
Fam. Ceratozetidae										
Ceratozetes minutissimus Willmann, 1951	x	x	x	x		x	x		c-s-eur - pal (med)	xe
Diapterobates humeralis (Hermann, 1804)				x		x			hol	si xe
Jugatala angulata (C.L. Koch, 1840)					x			x	c-eur	xe
Trichoribates berlesei Jacot, 1929	x		x				x	x	hol	eu
Trichoribates incisellus (Kramer, 1897)			x					x	hol	eu
Fam. Chamobatidae										
Chamobates birulai (Kulczynski, 1902)	x					x			pal	si
Chamobates interpositus Pschorn-Walcher, 1953	x					x	x		c-s-eur (med)	xe li mu
Chamobates pusillus (Berlese, 1895)	x					x			hol	eu
Chamobates voigtsi (Oudemans, 1902)				x		x			pal	si xe mu
Globozetes longipilus Sellnick, 1928				x		x			pal (med)	si xe

Fam. Cosmochthoniidae										
Cosmochthonius reticulatus Grandjean, 1947	x						x		cos (med)	xe
Phyllozetes emmae (Berlese, 1910)	x						x		cos (med)	xe
Fam. Crotoniidae										
Camisia biverrucata (C.L. Koch, 1839)			x	x		x			hol	si xe mu
Camisia horrida (Hermann, 1804)	x					x			hol	xe mu
Camisia segnis (Hermann, 1804)		x					x		hol - cos	xe mu
Camisia spinifer (C.L. Koch, 1836)				x		x			hol - cos	si xe
Heminothrus targionii (Berlese, 1885)			x			x			hol	si xe mu
Platynothrus peltifer (C.L. Koch, 1839)	x					x			hol - cos	eu
Fam. Cymbaeremaeidae										
Cymbaeremaeus cymba (Nicolet, 1855)	x			x		x	x		pal	xe mu li
Scapheremaeus reticulatus (Berlese, 1910)	x					x	x	x	c-s-eur (med)	si
Fam. Damaeidae										
Metabelba papillipes (Nicolet, 1855)			x			x			hol - cos	si mu
Metabelba parapulverosa Moritz, 1966	x			x		x		x	c-s-eur	eu
Metabelba pulverosa Strenzke, 1953		x				x	x		hol	eu
Fam. Damaeolidae										
Damaeolus asperatus (Berlese, 1904)	x					x			c-s-eur - pal (med)	si xe
Fosseremus laciniatus (Berlese, 1905)	x		x	x		x	x		hol - cos (med)	xe
Fam. Eniochthoniidae										
Eniochthonius minutissimus (Berlese, 1904)	x	x	x	x	x	x	x		hol - cos	eu
Fam. Eremaeidae										
Eremaeus hepaticus C.L. Koch, 1835	x					x			hol	si xe
Eueremaeus oblongus (C.L. Koch, 1836)				x		x			hol	si xe mu
Eueremaeus valkanovi (Kunst, 1957)	x	x	x	x	x	x	x	x	c-s-eur - pal (med)	xe mu
Fam. Euphthiracaridae										
Acrotritia ardua (C.L. Koch, 1841)	x	x	x	x	x	x	x		hol - cos	eu
Fam. Galumnidae										
Galumna lanceata (Oudemans, 1900)	x	x	x	x	x	x		x	pal	eu
Galumna tarsipennata Oudemans, 1914		x		x			x	x	pal (med)	xe
Pergalumna altera (Oudemans, 1915)	x	x	x		x	x	x	x	hol - cos	xe
Pergalumna formicaria (Berlese, 1914)		x	x	x			x	x	hol	xe mu
Pergalumna nervosa (Berlese, 1914)	x	x	x	x	x	x	x	x	hol - cos	eu
Pilogalumna crassiclava (Berlese, 1914)	x			x			x	x	pal (med)	si xe
Pilogalumna tenuiclava (Berlese, 1908)	x					x			hol	hy

	Site					Habitat				
	Säben	Trumbichl	Raffeil	Teis	Lajen	dry bushland	dry grassland	rocky steppe	General distribution	Habitat requirement
samples →	14	6	10	6	4	12	15	13		
Taxon *number of species →*	103	43	56	71	32	110	81	56		
Fam. Gymnodamaeidae										
Arthrodamaeus femoratus (C.L. Koch, 1840)	x						x		c-s-eur - pal (med)	xe mu
Arthrodamaeus reticulatus (Berlese, 1910)	x						x		c-s-eur (med)	xe
Gymnodamaeus barbarossa Weigmann, 2006				x		x			c-s-eur	xe
Gymnodamaeus irregularis Bayartogtokh & Schatz, 2009	x						x		c s Alps	xe
Gymnodamaeus meyeri Bayartogtokh & Schatz, 2009	x					x			c s Alps	xe
Plesiodamaeus craterifer (Haller, 1884)	x					x	x		pal (med)	si xe
Fam. Haplozetidae										
Haplozetes vindobonensis (Willmann, 1935)	x					x			pal - cos (med)	xe
Peloribates europaeus Willmann, 1935	x	x	x	x			x	x	hol (med)	xe
Protoribates capucinus Berlese, 1908	x		x	x		x	x		hol - cos	eu
Protoribates lophothrichus (Berlese, 1904)		x				x			hol - cos	si mu
Fam. Hermanniellidae										
Hermanniella septentrionalis Berlese, 1910	x					x	x		hol (med?)	si mu
Fam. Hypochthoniidae										
Hypochthonius rufulus C.L. Koch, 1835	x					x			hol - cos	eu
Fam. Liacaridae										
Adoristes ovatus (C.L. Koch, 1839)	x	x		x		x			hol	eu
Liacarus coracinus (C.L. Koch, 1840)	x					x			hol	eu
Xenillus athesis Schatz, 2004	x					x	x		Southern Alps	xe
Xenillus discrepans Grandjean, 1936	x						x		pal (med)	si xe
Xenillus tegeocranus (Hermann, 1804)				x		x			pal (med?)	eu
Fam. Licneremaeidae										
Licneremaeus licnophorus (Michael, 1882)	x			x		x			hol (med)	si xe mu
Licneremaeus sp.	x	x		x		x	x		Southern Alps	xe
Fam. Licnobelbidae										
Licnobelba latiflabellata (Paoli, 1908)	x					x	x		w-pal (med)	si xe
Fam. Licnodamaeidae										
Licnodamaeus pulcherrimus (Paoli, 1908)	x	x	x	x	x	x	x	x	c-s-eur - pal (med)	si xe
Licnodamaeus undulatus (Paoli, 1908)	x					x	x		c-s-eur - pal (med)	xe
Fam. Machuelllidae										
Machuella draconis Hammer, 1961		x				x			w-pal (med)	si xe

Fam. Malaconothridae										
Malaconothrus monodactylus (Michael, 1888)			x				x		hol - cos	si hy
Tyrphonothrus glaber (Michael, 1888)				x				x	hol	hy
Tyrphonothrus maior (Berlese, 1910)		x				x		x	cos	hy si
Fam. Micreremidae										
Micreremus brevipes (Michael, 1888)	x			x		x	x		pal	xe li mu
Fam. Mochlozetidae										
Podoribates longipes (Berlese, 1887)					x		x		hol	xe
Fam. Nanhermanniidae										
Nanhermannia nana (Nicolet, 1855)					x		x		hol - cos	hy
Fam. Neoliodidae										
Neoliodes theleproctus (Hermann, 1804)	x						x	x	c-s-eur - pal (med)	xe
Platyliodes scaliger (C.L. Koch, 1839)	x		x	x	x	x	x	x	hol (med)	xe mu
Fam. Nothridae										
Nothrus anauniensis Canestrini & Fanzago, 1876	x			x		x			hol - cos	eu
Fam. Oppiidae										
Berniniella bicarinata (Paoli, 1908)	x		x	x		x			pal - cos	eu
Berniniella conjuncta (Strenzke, 1951)	x					x			eur	hy si mu
Berniniella hauseri (Mahunka, 1974)	x					x			c s se eur (med)	si xe
Dissorhina ornata (Oudemans, 1900)	x					x			hol	eu
Microppia minus (Paoli, 1908)			x		x	x	x	x	hol - cos	eu
Multioppia glabra (Mihelčič, 1955)	x					x			pal (med)	si xe
Oppia nitens C.L. Koch, 1836			x			x		x	hol	eu
Oppiella falcata (Paoli, 1908) (*Oppiella*)	x					x			pal	si
Oppiella keilbachi (Moritz, 1969) (*Moritzoppia*)	x					x			pal	si xe
Oppiella nova (Oudemans, 1902) (*Oppiella*)	x	x	x	x	x	x	x	x	hol - cos	eu
Oppiella subpectinata (Oudemans, 1900) (*Rhinoppia*)		x					x		hol - cos	eu
Ramusella elliptica (Berlese, 1908)		x				x			hol (med)	si hy mu
Ramusella insculpta (Paoli, 1908) (*Insculptoppia*)			x	x	x	x	x		pal (med)	si xe
Subiasella quadrimaculata (Evans, 1952) (*Lalmoppia*)	x						x		pal	si xe
Fam. Oribatellidae										
Oribatella calcarata (C.L. Koch, 1835)	x					x			hol	si hy
Oribatella superbula (Berlese, 1904)	x						x		pal (med)	xe mu
Fam. Oribatulidae										
Oribatula caliptera Berlese, 1902	x	x	x			x	x		pal (med)	xe

	Site					Habitat				
	Säben	Trumbichl	Raffeil	Teis	Lajen	dry bushland	dry grassland	rocky steppe	General distribution	Habitat requirement
samples →	14	6	10	6	4	12	15	13		
Taxon *number of species →*	103	43	56	71	32	110	81	56		
Oribatula interrupta (Willmann, 1939)		x		x	x		x	x	pal	xe li mu
Oribatula tibialis (Nicolet, 1855)				x		x			hol - cos	eu
Phauloppia lucorum (C.L. Koch, 1840)	x		x			x	x	x	hol	xe li
Phauloppia rauschenensis (Sellnick, 1908)		x					x	x	pal	xe
Pseudoppia sp.	x				x		x	x	Southern Alps	xe
Zygoribatula exilis (Nicolet, 1855)	x		x			x			hol	eu
Zygoribatula glabra (Michael, 1890)	x	x	x	x	x	x	x	x	pal (med)	xe mu
Fam. Passalozetidae										
Passalozetes africanus Grandjean, 1932	x	x	x	x	x	x	x	x	hol (med)	xe
Passalozetes intermedius Mihelčič, 1954				x	x		x	x	pal (med)	xe
Passalozetes perforatus (Berlese, 1910)				x					pal (med)	xe
Fam. Phenopelopidae										
Eupelops claviger (Berlese, 1916)	x					x			c-s-eur - pal (med)	si mu
Eupelops torulosus (C.L. Koch, 1835)				x		x			pal	si hy
Peloptulus phaeonotus (C.L. Koch, 1844)	x	x	x	x	x	x	x	x	pal	eu
Fam. Phthiracaridae										
Atropacarus striculus (C.L. Koch, 1836)	x					x			hol - cos	eu
Phthiracarus laevigatus (C.L. Koch, 1844)	x			x		x			pal - cos	eu
Steganacarus applicatus (Sellnick, 1920)	x					x			w-pal	si
Fam. Punctoribatidae										
Minunthozetes pseudofusiger (Schweizer, 1922)	x		x			x	x		pal	xe li mu
Minunthozetes semirufus (C.L. Koch, 1841)	x		x	x		x	x	x	hol	eu
Mycobates parmeliae (Michael, 1884)	x						x		hol	xe li mu
Punctoribates punctum (C.L. Koch, 1839)	x			x	x		x	x	hol - cos	eu
Fam. Quadroppiidae										
Coronoquadroppia monstruosa (Hammer, 1979)	x		x	x		x			hol - cos (med?)	si
Quadroppia quadricarinata (Michael, 1885)	x		x	x		x	x		hol - cos	eu
Fam. Scheloribatidae										
Dometorina plantivaga (Berlese, 1895)	x	x	x	x	x	x	x	x	hol - cos	xe
Liebstadia humerata Sellnick, 1928	x					x			hol	xe mu
Liebstadia longior (Berlese, 1908)			x			x			c-s-eur - hol (med)	xe li mu

Liebstadia pannonica (Willmann, 1951)		x	x	x	x		x	x	hol (med)	xe
Liebstadia similis (Michael, 1888)	x					x	x	x	hol - cos	eu
Liebstadia willmanni Miko & Weigmann, 1996		x						x	c-eur	eu
Scheloribates laevigatus (C.L. Koch, 1835)	x	x				x	x	x	hol - cos	eu
Scheloribates latipes (C.L. Koch, 1844)			x	x	x	x	x	x	hol	eu
Scheloribates pallidulus (C.L. Koch, 1841)				x				x	hol - cos	eu
Fam. Scutoverticidae										
Lamellovertex caelatus (Berlese, 1895)	x		x				x	x	c-s-eur - pal (med)	xe li mu
Provertex kuehnelti Mihelčič, 1959		x						x	c-n-eur	xe li mu
Scutovertex minutus (C.L. Koch, 1835)	x			x			x	x	pal - cos	xe mu
Scutovertex sculptus Michael, 1879	x	x		x	x		x	x	c-s-eur - pal	xe mu
Fam. Sphaerochthoniidae										
Sphaerochthonius splendidus (Berlese, 1904)	x					x	x		hol - cos (med)	xe
Fam. Suctobelbidae										
Suctobelba altvateri Moritz, 1970	x			x		x			c-s-eur - w-pal (med)	si hy mu
Suctobelba secta Moritz, 1970	x	x	x	x		x		x	eur	si
Suctobelba trigona (Michael, 1888)	x					x			pal	eu
Suctobelbella acutidens (Forsslund, 1941)			x	x		x	x		hol	eu
Suctobelbella forsslundi (Strenzke, 1950)	x					x			pal	eu
Suctobelbella nasalis (Forsslund, 1941)	x	x	x	x		x	x		pal - cos	eu
Suctobelbella sarekensis (Forsslund, 1941)	x	x	x	x	x	x	x	x	hol	eu
Suctobelbella subcornigera (Forsslund, 1941)	x	x	x	x		x			pal - cos	eu
Suctobelbella subtrigona (Oudemans, 1900)	x	x		x		x			hol - cos	eu
Fam. Tectocepheidae										
Tectocepheus minor Berlese, 1903	x		x	x	x	x		x	hol - cos	si xe
Tectocepheus sarekensis (Trägårdh, 1910)	x	x	x	x	x	x	x	x	hol - cos	eu
Tectocepheus velatus (Michael, 1880)	x	x	x	x	x	x	x	x	hol - cos	eu
Fam. Thyrisomidae										
Banksinoma lanceolata (Michael, 1885)			x			x			hol	eu
Fam. Trhypochthoniidae										
Trhypochthonius tectorum (Berlese, 1896)	x	x	x	x			x	x	hol - cos	xe mu
Fam. Zetorchestidae										
Microzetorchestes emeryi (Coggi, 1898)	x	x	x	x		x	x	x	pal (med)	xe mu
Zetorchestes flabrarius Grandjean, 1951	x			x		x		x	c-s-eur (med)	si xe mu

In this context I want to discuss the term 'xerophilous' (see also Höpperger & Schatz 2013). According to Schäfer (2003) this term refers to organisms that prefer dry habitats. However, due to the mere occurrence in xeric habitats no direct proof of preference for this habitat can be recognized, since it could only mean a greater resistance to drought. In contrast, 'xerobiont' organisms are bound to xeric habitats. In this study the term 'xerophilous' is used broadly for species that are found predominantly in xeric habitats. Especially taxa from the southern or 'mediterranean' fauna require higher temperatures, usually coupled with xerophily (or tolerance of desiccation). These species occur mainly in south-exposed xerothermic sites (Schuster 1960).

3.3 Characterization of the sites

Säben is situated at an altitude of about 600–700 m a.s.l. A total of 103 species were found, the highest diversity of all investigated areas. Some conspicuous xerophilous species in the shrub forest and dry grassland are *Damaeolus asperatus*, *Gymnodamaeus meyeri*, *Plesiodamaeus craterifer*, *Sphaerochthonius splendidus*, *Subiasella quadrimaculata*, *Xenillus athesis*, and *Eupelops claviger* (the latter species is silvicolous).

One small hill northward of the monastery (46°38,71′N, 11°34,19'E, 680 m a.s.l.) with rocky steppe and dry grassy patches under *Fraxinus ornus* harbours an outstanding assemblage of very rare oribatid species (e.g. *Arthrodamaeus femoratus*, *Cosmochthonius reticulatus*, *Gymnodamaeus irregularis*, *Phyllozetes emmae*).

Trumbichl is a smaller site at 880 m a.s.l. Among the total of 46 species some remarkable findings are *Machuella draconis*, *Phauloppia rauschenensis*, *Provertex kuehnelti*, also *Protoribates lophothrichus*, *Ramusella elliptica* (the latter two species are silvicolous).

Raffeil hill (about 740 m a.s.l.): Among the total of 56 species some rarities are *Cultroribula lata* and *Lamellovertex caelatus.*

Teis (1000 m a.s.l.): A total of 71 species were collected. Some remarkable species are *Gymnodamaeus barbarossa*, *Liochthonius perelegans*, *Micreremus brevipes*, and *Passalozetes perforatus.*

The hill Wasserbühl near **Lajen** is situated at 1100 m a.s.l. In the few samples taken 32 species were found.

Table 2. Oribatid mites in dry grasslands in the Eisack Valley / Valle Isarco (South Tyrol). Habitat requirements of species and proportion of 'mediterranean species' in each site and habitat (data from the literature, see Tab. 1 and text). Regarding the terms 'xerophilous' 'mediterranean' see text.

species number	all sites	Säben	Trum bichl	Raffeil	Teis	Lajen	shrub forest	dry grass land	rocky steppe
spp. total	**150**	**103**	**43**	**56**	**71**	**32**	**110**	**81**	**56**
euryoecious	**50**	35	18	25	29	13	42	25	21
silvicolous	**47**	29	6	13	18	4	42	13	10
xerophilous	**79**	54	21	27	37	18	49	52	31
hygrophilous	**12**	6	2	1	3	1	9	2	2
microhabitats:									
lichenicolous	**10**	7	2	4	3	1	6	8	4
muscicolous	**36**	54	11	13	17	6	25	19	13
mediterranean	**46**	35	12	16	22	8	32	31	15

percentage	all sites	Säben	Trum bichl	Raffeil	Teis	Lajen	shrub forest	dry grass land	rocky steppe
spp. total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
euryoecious	33.3	34.0	41.9	44.6	40.8	40.6	38.2	30.9	37.5
silvicolous	31.3	28.2	14.0	23.2	25.4	12.5	38.2	16.0	17.9
xerophilous	52.7	52.4	48.8	48.2	52.1	56.3	44.5	64.2	55.4
hygrophilous	8.0	5.8	4.7	1.8	4.2	3.1	8.2	2.5	3.6
microhabitats:									
lichenicolous	6.7	6.8	4.7	7.1	4.2	3.1	5.5	9.9	7.1
muscicolous	24.0	52.4	25.6	23.2	23.9	18.8	22.7	23.5	23.2
mediterranean	30.7	34.0	27.9	28.6	31.0	25.0	29.1	38.3	26.8

Table 3. Sørensen index of oribatid mite assemblages from five sampling sites in the Eisack Valley / Valle Isarco (South Tyrol). Species in common upper left, Sørensen index bottom right, values >50% similarity highlighted in grey; highest values marked in bold.

a) species in common and similarity coefficient (all species)

	Lajen	Teis	Raffeil	Trumbichl	Säben	spp. total
Säben	23	47	38	28	-	103
Trumbichl	18	29	26	-	38.4	43
Raffeil	22	38	-	52.5	47.8	56
Teis	25	-	**59.8**	50.9	54.0	71
Lajen	-	48.5	50.0	48.0	34.1	32

b) species in common and similarity coefficient (xerophilous species)

	Lajen	Teis	Raffeil	Trumbichl	Säben	spp. total
Säben	12	21	18	13	-	54
Trumbichl	9	15	13	-	**76.5**	21
Raffeil	11	18	-	54.2	44.4	27
Teis	13	-	56.3	51.7	46.2	37
Lajen	-	47.3	48.9	46.2	33.3	18

Some remarkable species are *Podoribates longipes*, *Pseudoppia* sp., and *Jugatala angulata*, the latter species frequently found at higher altitudes.

Table 3 gives the number of species present in both sites and the Sørensen index for all combinations of sampling sites. The Sørensen-Index was calculated with all species (a) and with xerophilous species only (b). The sampling in all sites was mainly restricted to the dry habitats, thus the species similarity is generally high, highest between Raffeil and Teis (60 %), lowest between Säben and Trumbichl (38 %). Considering only xerophilous species, the highest similarities are observed between Säben and Trumbichl (76 %) and between Raffeil and Teis (56 %), the lowest between Säben and Lajen (33 %). Most values range within similar percentages and the minor differences might be caused by different size of the sites (Säben is by far the most extended site, also most samples were taken there, in Lajen the dry sites are relatively small). Thus, Säben and Trumbichl harbour the most representative xerophilous oribatid fauna of dry grasslands.

A total of 14 species occur in all 5 sites, among them the xerophilous species *Dometorina plantivaga*, *Eueremaeus valkanovi*, *Licnodamaeus pulcherrimus*, *Passalozetes africanus*, *Zygoribatula glabra*. On the other end of the scale 80 species were found in only one site, among them 29 species with one specimen, 7 with 2 specimens.

3.4 Remarkable species records

***Arthrodamaeus reticulatus* (Berlese, 1910)** (Fam. Gymnodamaeidae): General distribution: Central, South, West Europe, northern Africa; preferably in dry habitats. Eisack valley: single records in Säben, in dry grassland.

***Carabodes minusculus* Berlese, 1923** sensu Bernini 1976 (Fam. Carabodidae): Taxonomic remark: This species is very similar to *Carabodes schatzi* Bernini, 1976. The latter species is frequent at higher altitudes of the Central and Southern Alps (Bernini 1976, Schatz 2018). Among the morphological differences between both species (Bernini 1976) one of the most striking characters is the shape of the notogastral setae (longer, thin and pointed in *C. schatzi* versus thicker, serrate and blunt in *C. minusculus*). General distribution: Bernini (1976) recorded this species from several localities in South Europe in dry habitats, it is also known from the western and southeastern Palaearctic including Central Asia, possibly introduced into the U.S.A. (Hammer 1969). First record for South Tyrol. Earlier records of '*C. minusculus*' in mountains around the Brenner Pass (Schmölzer 1994) are considered to be *C. schatzi* (Schatz 2018). Eisack valley: Säben, Teis, Lajen, in dry grassland and rocky steppe.

***Cosmochthonius reticulatus* Grandjean, 1947** (Fam. Cosmochthoniidae): General distribution: southern Palaearctic, Nearctic and Neotropical regions; preferably in dry habitats. First record for South Tyrol, known from Sondrio and South Italy. Eisack valley: Säben, in dry grassland.

***Damaeolus asperatus* (Berlese, 1904)** (Fam. Damaeolidae): General distribution: southern Palaearctic, Nearctic; preferably in dry and woody habitats. Eisack valley: Säben, in dry shrub forest. Schuster (1965) reported this species from the same site in small stands of *Castanea sativa* and *Quercus pubescens.*

***Eupelops claviger* (Berlese, 1916)** (Fam. Phenopelopidae): Taxonomic remark: This species is very similar to *Eupelops acromios* (Hermann, 1804). The assignment of the specimen from Säben to *E. claviger* was based on the close-by position of the notogastral setae *lp*/*h3*, distally broadened rostral setae, and setae *h1* and *p1* longer than *p2* and *p3* (Mahunka 1992). Body length 740 µm. General distribution: Italy: Prov. Sondrio (type locality), Switzerland: Grisons, Southeast Europe, southern and eastern Palaearctic; preferably in woody habitats, also in moss. First record for South Tyrol. Eisack valley: Säben, single record in submediterranean shrub forest in dry moss.

***Gymnodamaeus irregularis* Bayartogtokh & Schatz, 2009** (Fam. Gymnodamaeidae): General distribution: Second record of this recently described species, originally found in a dry habitat in the Inn Valley near Mötz in North Tyrol, Austria (Bayartogtokh & Schatz 2009). The species seems to prefer dry habitats. First record for Italy and South Tyrol. Eisack valley: Säben, in dry grassland. The species was transferred without justification to the genus *Joshuella* by Subías (2009-2018).

***Gymnodamaeus meyeri* Bayartogtokh & Schatz, 2009** (Fam. Gymnodamaeidae): General distribution: Central Eastern Alps, in South Tyrol hitherto only found in Matscher Tal / Val di Mazia, in a larch forest pasture (Schatz 2017). The species seems to prefer dry habitats. Eisack valley: Säben, single record in dry shrub forest. The species was transferred without justification to the genus *Joshuella* by Subías (2009-2018).

***Lamellovertex caelatus* (Berlese, 1895)** (Fam. Scutoverticidae): General distribution: southern Palaearctic; preferably in dry habitats, in lichens and moss. Eisack valley: Säben, Raffeil, in dry grassland and rocky steppe.

***Licneremaeus* sp.** (Fam. Licneremaeidae): Taxonomic remark: An undescribed species, morphological similarities to *L. giustii* Bernini, 1973. A description is in preparation. General distribution: First record for South Tyrol. Säben, Trumbichl, Teis, in dry grassland and dry shrub forest.

***Licnobelba latiflabellata* (Paoli, 1908)** (Fam. Licnobelbidae): General distribution: southwestern Palaearctic; preferably in dry deciduous forests (Weigmann et al. 2015). Eisack valley: Säben, in dry grassland and shrub forest.

***Liochthonius perelegans* Moritz, 1976** (Fam. Brachychtoniidae): General distribution: Central, Southwest, East Europe. A very rare species, probably sometimes overlooked – this species is among the smallest oribatid mite species (length of present specimens n=3, 165–175 × 95–102 µm). Known from dry deciduous forests (Weigmann et al. 2015). First record for Italy and South Tyrol, in North Tyrol recorded in Obergurgl (Festkogel 3035 m a.s.l, Schatz 2004). Eisack valley: Raffeil, Teis, single records in dry grassland.

***Machuella draconis* Hammer, 1961** (Fam. Machuellidae): General distribution: southwestern Palaearctic, Central America; preferably in dry deciduous forests (Weigmann et al. 2015). First record for South Tyrol. Eisack valley: Trumbichl, single record in dry shrub forest.

***Metabelba parapulverosa* Moritz, 1966** (Fam. Damaeidae): General distribution: Central, South, Southwest Europe; preferably in open habitats, also in mountainous regions (Weigmann et al., 2015). First record for South Tyrol. Eisack valley: Säben, Teis, in dry shrub forest.

***Phyllozetes emmae* (Berlese, 1910)** (Fam. Cosmochthoniidae): General distribution: southern Palaearctic, Oriental, Nearctic, Neotropical and Australian regions, mainly tropical and subtropical; preferably in warm and dry habitats. A very rare species, small and whitish, probably sometimes overlooked (length of present specimen 242 × 93 µm). First record for South Tyrol. Eisack valley: Säben, single record in dry grassland.

***Plesiodamaeus craterifer* (Haller, 1884)** (Fam. Gymnodamaeidae): General distribution: South Tyrol: Klausen, Castelfeder (Höpperger & Schatz 2013), southern Palaearctic; preferably in dry and woody habitats. Eisack valley: Säben, in dry grassland and shrub

forest. Schuster (1965) reported this species from the same site in small stands of *Castanea sativa* and *Quercus pubescens.*

***Pseudoppia* sp.** (Fam. Oribatulidae): Taxonomic remark: An undescribed species, morphological similarities to *P. mediocris* (Mihelčič, 1957). A description is in preparation. General distribution: already found in South Tyrol (Schatz 2018), North Tyrol (Schatz & Fischer 2015, sub *Pseudoppia mediocris*), Carinthia (Perlinger & Schatz 2009, sub *Pseudoppia mediocris*). Eisack valley: Säben, Lajen, single records in dry grassland and rocky steppe.

***Scapheremaeus reticulatus* (Berlese, 1910)** (Fam. Cymbaeremaeidae): General distribution: South Tyrol: Weißenbach im Sarntal (Schatz & Fischer 2016), Central, South Europe; in dry, woody habitats. Eisack valley: Säben, in dry grassland, shrub forest and rocky steppe.

***Sphaerochthonius splendidus* (Berlese, 1904)** (Fam. Sphaerochthoniidae): General distribution: southern Palaearctic, Oriental, Ethiopian, Nearctic, Neotropical and Australian regions, semicosmopolitan; preferably in warm and dry habitats. Eisack valley: Säben, in dry grassland and shrub forest.

***Xenillus athesis* Schatz, 2004** (Fam. Liacaridae): General distribution: only known from South Tyrol: dry forests along river Etsch / Adige near Bolzano / Bozen and in Castelfeder (Schatz 2018). The species seems to prefer dry habitats. Eisack valley: Säben, in dry grassland and shrub forest.

***Xenillus discrepans* Grandjean, 1936** (Fam. Liacaridae): General distribution: southern Palaearctic; preferably in deciduous forests (Weigmann et al. 2015). Eisack valley: Säben, single record in in dry grassland.

4. Conclusions

The investigated sites in the Eisack valley host oribatid species assemblages which are characteristic for dry habitats in the valleys of the southern Alps. The percentage of xerophilous species in all sites is high and seems to be linked to the size of the site and the habitat composition of surrounding areas.

Among all sites a small hill in Säben contains an outstanding oribatid fauna – some very rare xerophilous species occur there. The high species number in Raffeil and Teis as well as the high similarity of these sites is also remarkable and shows the importance of even smaller sites as refuges for rare species assemblages.

It can be concluded that the few remaining dry grasslands in the Eisack Valley are still important as stepping stones for 'mediterranean' species from the South to the Central Alps. Due to their specific ecological requirements oribatid species are valuable indicators for habitat quality of dry grasslands and should be considered in the planning of management and conservation. Dry grasslands are critically endangered by succession and overgrowing with shrubs, by agricultural eutrophication or by anthropogenic settlement pressure. Some of the investigated sites are protected areas by the Nature Conservation Act of the Autonomous Province Bolzano. It is to be hoped that these unique habitats for an exceptional soil fauna will be conserved for the future.

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