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Centipede assemblages (Chilopoda) in high-altitude landforms of the Central-Eastern Italian Alps: diversity and abundance

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Abstract
Centipedes (Chilopoda) are widespread and abundant predators in several kind of habitats, from forests to caves. Very few quantitative data are currently available for alpine habitats, specifically those located at high-altitudes. In this paper, we analysed data on centipedes collected by pitfall traps on different high-altitude landforms of the Central-Eastern Italian Alps, specifically on rock glaciers, debris-covered glaciers, glacier forelands, stable slopes, and scree slopes. We investigated the species richness and abundance (activity density) of individuals in each landform and the relationships between species occurrence and environmental variables in the investigated landforms. The obtained results highlighted non-significant differences in species richness between the landforms, but significant differences in individual abundance and species distribution. Soil organic matter, soil gravel percentage and altitude resulted the main variables affecting the species distribution; a clear preference for landforms located near the treeline was highlighted. *Lithobius lucifugus* resulted the dominant and most common species as well as the only species able to colonise debris-covered glaciers.

Keywords Chilopods · Debris-covered glaciers · Mountains · Organic matter · Rock glaciers · Scree slopes

1 Introduction

Centipedes (Chilopoda) are a group of terrestrial arthropods, mostly nocturnal, chiefly predators of small invertebrates. Epigean or edaphic, also present in caves and in the subterranean environment in general, they occur from sea level up to 4000 m, colonizing a wide range of habitats (see Lewis 1981; Minelli and Iovane 1987; Voigtländer 2005; Zapparoli and Minelli 2007; Minelli 2011). Approximately 3300 species are recognized to date (Bonato et al. 2016), near 490 of which occur in Europe (Enghoff 2014) and about 160 in Italy (Zapparoli and Minelli 2007).

Generally, centipedes exhibit a wide geographic distribution, although species with a narrow or restricted range are also known; level of endemism is, however, moderate (Zapparoli and Minelli 2007).

Although the knowledge on taxonomy, geographic distribution and habitat preferences of some species is still incomplete, they are regarded as useful biogeographic (e.g., Vigna Taglianti et al. 1999; Edgecombe and Giribet 2003; Simaiakis and Mylonas 2008) and ecological indicators (e.g., Parisi et al. 2005; Tuf and Tufová 2008; Dunger and Voigtländer 2009).

High-altitude habitats generally host poor centipede species assemblages; despite this, information on centipede diversity and ecology are few. Sparse records are available in more or less wide general synthesis papers (e.g. by Mani (1962), Beron (1999, 2008a, 2008b), Mani and Giddings (2012)).

The centipede fauna of Central-Eastern Italian Alps has been the object of intense faunistic research since the second half of the last century (cf. Attems 1949). New records on high-altitude habitats have been published until the end of twentieth century (Minelli 1981, 1988, 1991; Moser, 1999;

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Thaler 1989, 1992, 1994). On the other hand, very few data are available on the quantitative composition of centipede assemblages in high-altitude landforms (see Minelli 1988; Gobbi et al. 2006) and relationships with soil characteristics are still unknown.

The physiognomy of high-altitude Alpine areas is mainly characterised by the presence of the following landforms: alpine grassmats, screes, glacier forelands, rock glaciers and glaciers (some of them transforming into debris-covered glaciers).

This paper aims at investigating, from the quantitative point of view, the (i) centipede species assemblages from a range of different high-altitude landforms of the Central-Eastern Italian Alps and (ii) to describe the patterns of species distribution and their relationships with environmental variables in the investigated landforms.

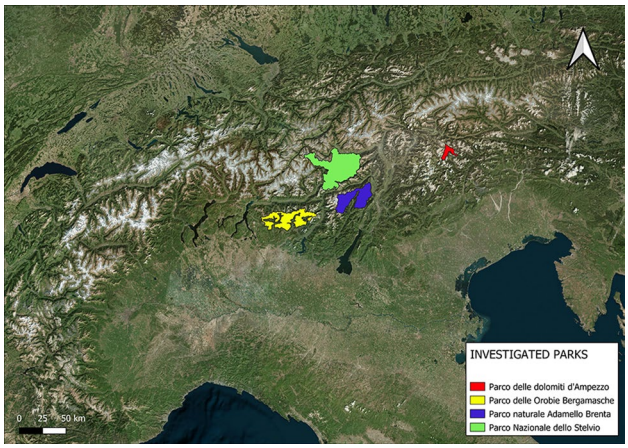

Fig. 1 The four Parks in which centipedes were collected; 48 sampling points in Parco delle Dolomiti d'Ampezzo, 39 in Parco Adamello Brenta, 11 in Parco Nazionale dello Stelvio and 43 in Parco Orobie Bergamasche

2 Materials and methods

2.1 Dataset available and study area investigated

A database of chilopod species occurrence and abundances from a range of different high-altitude sampling locations, located in four Parks of the Central-Eastern Italian Alps (Parco Nazionale dello Stelvio [46° 23′ 29, 84″ N, 10° 36′ 30, 59″ E]; Parco delle Orobie Bergamasche [45° 58′ 58, 51″ N, 09° 53′ 03, 44″ E]; Parco Naturale Adamello Brenta [46° 07′ 14, 96″ N, 10° 45′ 01, 41″ E] and Parco delle Dolomiti d'Ampezzo [46° 37′ 13, 46″ N, 12° 06′ 34, 02″ E]), was compiled (Fig. 1, Appendix 1). A total of 141 sampling points (pitfall traps), ranging from 1925 to 2650 m asl, was analysed (Appendix 1).

Pitfall traps consisted of plastic vessels (diameter 7 cm, height 10 cm) baited with a mixture of wine-vinegar and salt. The traps were active over the entire snow-free seasons, from early July to late September.

One hundred and twenty four sampled points provided information about the abundance, the remaining (only 17; 13%) have presence/absence data and were not used in statistical analysis.

The sampling points providing data of chilopods occurrence were grouped into seven high-altitude landforms type: active rock glacier (RG_A; 8 traps), relict rock glacier (RG_R; 4 traps), debris-covered glacier (DG; 8 traps), glacier foreland/iceless moraine (less than 100 years old; F1; 67 traps), glacier foreland/iceless moraine (more than 100 years old; F2; 23 traps), stable slope (VS; 12 traps), scree slope (GG, 17 traps). For each sampling point, the following variables were recorded: altitude (m asl); bare ground (%); soil parameters: gravel %, organic matter (g/kg) and pH; aspect (°); number and type of sampled species; and abundance of individuals or presence/absence data.

The sampled specimens are stored at the MUSE-Science Museum of Trento (Italy) and in the collection of MZ.

2.2 Statistical analysis

Trap activity during the snow-free period depends by the altitude of each trap (i.e. traps at high elevations worked for less days respect to traps located at lower elevations). Therefore, to obtain comparable data among traps, the number of centipede individuals collected in each trap was transformed in "activity density" (AD) (sensu Brandmayr et al. 2005, but also known as "trapping rate" see Vater 2011) using the following formula [No. of individuals/(days of trap activity)]. The linotaenid geophilomorph *Strigamia transsilvanica* (Verhoeff, 1928) was not sampled by pitfall traps, because only sampled by hand searching, thus, for this species, there are no data on its activity density; consequently, it was not considered in the statistical analysis.

It is worth to note that pitfall trapping best samples the epigeic component of the centipede assemblage of a given area, mostly represented by lithobiomorphs, together with some scolopendromorphs (*Cryptops* spp.) and some geophilomorphs (*Strigamia* spp.) species. This sampling method is not sensitive to the edaphic component of these assemblages, mostly represented by geophilomorph species (see Minelli 1981).

Species richness was calculated summing the number of species found in each trap, while average activity density was calculated using activity density data recorded by pitfall traps in each landform type. Then, the percentage of total activity and the frequency of occurrence were calculated for each species in order to highlight the most active and common species.

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Kruskal–Wallis test was performed on species richness and activity density to compare species richness and total activity density among landform types (Wayne 1990). Performing the Kruskal–Wallis test was made possible by the fact that the traps were spatially independent from each other, thus the assumption of independence of the observations was satisfied (Theodorsson-Norheim 1986). When we obtained a significant difference among landform, a Dunn post hoc test was performed.

To describe the patterns of species distribution and their relationships with environmental variables, canonical correspondence analysis (CCA) was used (Hammer et al. 2001). Bare ground and gravel percentage were arcsin $\sqrt{(p/100)}$ transformed; altitude, pH, organic matter were natural log transformed, exposure were $-\cos(x)$ transformed to normalize the distribution.

3 Results

A total of 11 species of centipedes were sampled (Table 1). Considering the whole dataset (presence/absence plus activity density data), the species more frequently sampled (percentage of occurrence) in the considered landforms was *Lithobius lucifugus* (88,6% of occurrence), while the rest of the species were below 12%. When we consider only activity density data (124 sampling points), the most frequently occurring species in each landform were *L. lucifugus* (6 landforms out of 7), *Eupolybothrus tridentinus* and *L.*

Table 1 List of the centipede species collected in each landform type

Landform type	Debris-covered glaciers (DG)	Glacier foreland/iceless moraines (< 100 years) (F1)	Glacier foreland/iceless moraines (> 100 years) (F2)	Scree slopes (GG)	Active rock glaciers (RA_A)	Relict rock glaciers (RG_R)	Stable slopes (VS)	aAD
Average altitude (m asl) ± SD	2380 ± 208	2350 ± 191	2223 ± 170	2249 ± 95	2488 ± 58	2268 ± 126	2355 ± 65	
Eupolybothrus tridentinus (Fanzago, 1874)			0.002	0.001	0.003		0.004	0.002
Eupolybothrus longicornis (Risso, 1826)			0.001			0.013		0.007
Lithobius agilis C.L. Koch, 1847		0.005	0.022	0.002				0.010
Lithobius castaneus Newport, 1844						0.008		0.008
Lithobius lucifugus L. Koch, 1862	0.026	0.097	0.045	0.020	0.029		0.076	0.049
Lithobius sp. gr. *mutabilis/latro*					0.013	0.004		0.008
Lithobius pellicensis Verhoeff, 1934				0.002		0.004		0.003
Lithobius tricuspis Meinert, 1872			0.009	0.00	0.004	0.008	0.008	0.008
Lithobius dentatus C.L. Koch, 1844			0.004					0.004
Lithobius nodulipes Latzel, 1880		2	0.002					0.002

To each species corresponds the average activity density recorded in each landform type; aAD represents the average activity density recorded for each species in the whole dataset. *Strigamia transsilvanica* (Verhoeff, 1928) was excluded, because only sampled by hand-searching

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tricuspis (both in 5 out of 7 landforms) (Table 1). For what concern, the average activity density (aAD) values recorded for each species in each landform type, the most active species was *L. lucifugus* (aAD = 0.049) followed by *L. agilis* (aAD = 0.01) (Table 1).

Species richness did not show any significant difference among landforms (Kruskal–Wallis test: $X^2 = 7.24$; $p = 0.07$); conversely, total activity density shows significant differences (Kruskal–Wallis test: $X^2 = 20.19$; $p = 0.002$). Specifically, total activity density of Chilopoda assemblages collected on DG and GG is significantly lower respect to the total activity density recorded in VS, F1 and F2 (Fig. 2, Table 2).

CCA revealed differences in chilopod species distribution in relation to the analysed environmental variables (Table 3, Fig. 3). Specifically, most of the variance is explained by Axis 1 (39.5%) and Axis 2 (35.3%). As shown in Fig. 3, Axis 1 is mainly explained by the negative correlation among altitude and organic matter gradient, while Axis 2 among bare ground and gravel percentage. The occurrence of the sampled species is affected by the considered environmental variables. In general, most of the species avoid terrains located at the higher altitudes preferring those located at lower elevation where soil organic matter is higher. Aspect has a very short vector, thus it has a weak effect on the species distribution. *Lithobius* sp. gr. *mutabilis/latro*, *L. tricuspis* and *Eupolybothrus longicornis* are mainly linked to vegetated (= low bare ground percentage) and sandy/silty soils (= low gravel percentage). *L. pellicensis* and *L. castaneus* prefer terrains with high organic matter. *L. dentatus, L. nodulipes* and *L. agilis* are mainly linked to terrains located at the lower altitudes. *L. lucifugus* instead is not linked to any specific variable. In addition, CCA highlights that the chilopod assemblages colonising the sampled glacier forelands (F1 and F2, square and diamonds, quadrant 1) are quite different respect to the centipede assemblages inhabiting the rock glaciers (RG_A and RG_R, black dot and fill square) and scree slopes (GG, X, quadrant 2) (Fig. 3).

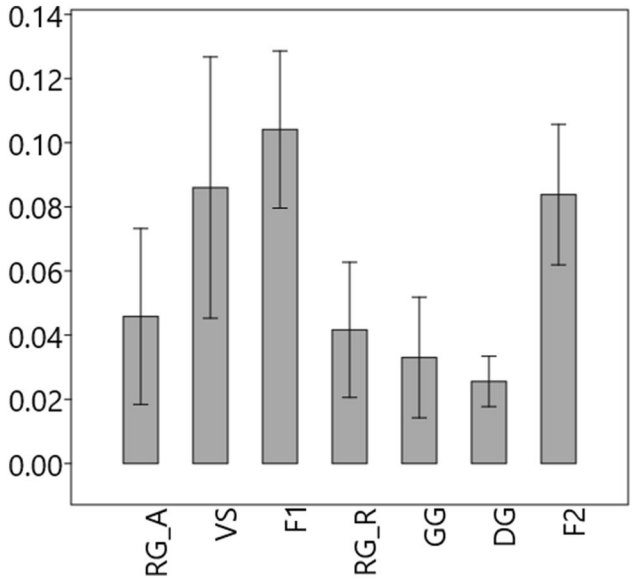

Fig. 2 Chilopods total activity density (*y*-axis) in each landform type (RG_A = active rock glaciers, RG_R = relict rock glaciers, DG = debris-covered glaciers, F1 = glacier foreland/iceless moraines (less than 100 years old), F2 = glacier foreland/iceless moraines (more than 100 years old), VS = stable slopes, GG = scree slopes). The whisker intervals represent a 95% confidence interval based on the standard error

4 Discussion

The obtained checklist of species colonizing high-altitude landforms of the Central-Eastern Italian Alps could be partially affected by the sampling method used. Pitfall traps are able to collect mostly ground-dwelling arthropods, thus the endogeic centipede species living in deeper soil levels—chiefly, the geophilomorph centipedes, except for *Strigamia* spp., at least in the Western Palearctic—were probably not sampled. Nevertheless, our results provide original insights into the centipede assemblages living in high-altitude Alpine landforms and how each species correlates with the main environmental variables driving the physiognomy of these landforms.

Even if species richness did not experience any significant variation in relation to the investigated landform type, the *p* value (0.068) is slightly greater than the significance level, in

Table 2 Dunn's post hoc values showing the significant differences found among the analysed landforms

	VS	F1	RG_R	GG	DG	F2
RG_A	0.181	0.072	0.962	0.471	0.354	0.107
VS		0.899	0.307	*0.027*	*0.021*	0.943
F1			0.209	*0.002*	*0.002*	0.948
RG_R				0.532	0.421	0.244
GG					0.783	*0.007*
DG						*0.006*

In italic the significant values

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Table 3 CCA scores of the species and the environmental variables

CCA_scores	Axis 1	Axis 2	Axis	Eigenvalue	%	Permutation test (999 permutations)	Eigenval	*p*
Eupolybothrus tridentinus	0.318	0.512	Axis 1	0.292	39.55	Axis 1	0.292	0.005
E_longicoirnis	1.453	1.659	Axis 2	0.261	35.3	Axis 2	0.261	0.001
Lithobius agilis	2.362	−1.311						
L_castaneus	1.286	2.303						
L_lucifugus	−0.421	−0.149						
*L*_sp. gr. *mutabilis/latro*	0.248	4.557						
L_pellicensis	2.186	1.517						
L_tricuspis	1.189	3.612						
L_dentatus	4.691	−0.394						
L_nodulipes	3.579	−0.476						
Altitude	−0.563	0.072						
Bare_ground	−0.001	−0.507						
Gravel	0.066	−0.287						
Organic_matter	0.505	0.279						
pH	−0.259	−0.351						
Aspect	0.034	−0.139						

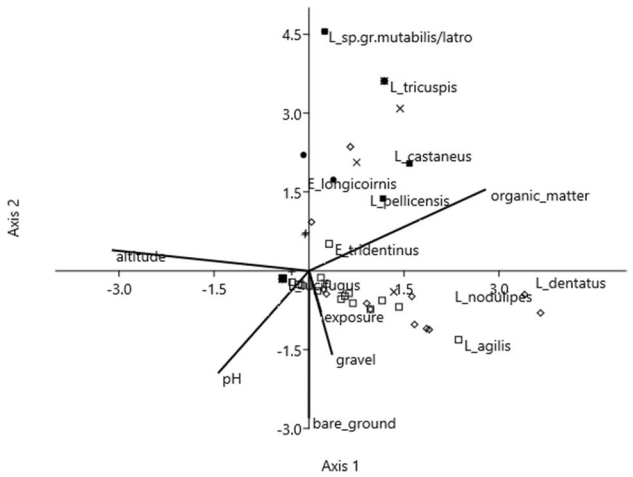

Fig. 3 CCA triplot of the distribution of chilopod species in relation to the six environmental variables (RG_A = black dot; VS = plus; F1 = square; GG = X; RG_R = Fill square; DG = O; F2 = diamond)

fact debris-covered glaciers have the lowest species richness due to the presence of just one species: *Lithobius lucifugus*.

Centipedes resulted particularly abundant on stable slopes and along glacier forelands, thus in the landforms with the higher vegetation cover if compared with the rest of the landforms which are characterised by high and deep stony cover. This confirms the observation performed by Gobbi et al. (2006) along an Alpine glacier foreland (Forni glacier foreland, Central Italian Alps) along which they observed a preference of centipedes for mature soils.

Canonical Correspondence Analysis highlighted that most of the recorded species has a clear preference for landforms located at the lower elevations (e.g., around 2000–2200 m asl, near the treeline), thus those ensuring the higher level of organic matter, which is proxy of vegetation cover, and consequently more acid soils. Low elevation, high organic matter, and low gravel percentage are the variables that mainly correlated with the recorded centipedes; the landform type seems to be of secondary importance since CCA did not cluster specific landforms.

Here, we present a synthesis of the few data available about the chorotype, altitudinal range and habitat preferences of the Italian populations of the recorded species; data were according to Minelli and Iovane (1987), Minelli (1988) and unpublished records by one of us (MZ), the chorotype refers to Vigna Taglianti et al. (1999).

- *Eupolybothrus tridentinus*: Central European; 500–2200 m; mostly in mesophilous woodlands; also in caves.
- *E. longicornis*: South European (Alpine endemic); 440–2450 m; mostly 800–2200 m; mainly in woodlands, coniferous and broadleaved forests.
- *Lithobius agilis*: European; 200–2300 m; woodland species; also in caves.
- *L. castaneus*: South European; 0–2600 m, mostly 600–2000; the most frequent *Lithobius* species in many woodlands types of Peninsular Italy, Sicily and Sardinia, for instance with *Quercus cerris* and *Fagus*; much less common in the beech communities of N Italy; also in "calanchi" and dunes; one record from *Eucalyptus* plantation; sometimes in caves.

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- *L. lucifugus*: European; 200–2475, mostly 1000–2300 m; mostly in open habitats, both of montane and alpine horizons and of lowlands, but also in woodlands, sometimes in caves.
- *L. pellicensis*: South European (Alpine endemic); altitudinal range and habitat preferences poorly known.
- *L. tricuspis*: Central European; 200–2250 m; seldom in alpine grassland; mostly in woodlands; also in caves.
- *L. dentatus*: Central European; 490–1500 m; mostly in montane and alpine woodlands; seldom in caves.
- *L. nodulipes*: Central European; 20–2000 m; mostly in alpine or montane habitats.

The information provided on the sampled species give us the following information: (i) two (18%) of the sampled species are endemic of the Southern Alps: *Eupolybothrus longicornis* and *Lithobius pellicensis*; (ii) all the sampled species belong to European chorotypes, mostly Central European; (iii) most of the sampled species are more frequently detected in mesophilous montane forest habitats. Our data improved the knowledge about the altitudinal range of the sampled species increasing the range to higher limits.

In addition, our data clearly highlighted that *Lithobius lucifugus* resulted the species with: (i) the higher altitudinal range (it was sampled until 2650 m asl), (ii) the wider landforms preference, since it was collected in almost all the landforms, (iii) the occurrence in the most harsh and climate-limited landform, the debris-covered glaciers. Based on these evidences *L. lucifugus* can be classified as species typical of high-altitude landforms of the Central-Eastern Alps.

L. lucifugus is known to inhabit at various underground habitats, from screes to caves (Haľková et al. 2020); its habitat preference clearly explains the wide distribution in most of the high-altitude landforms which are characterised by ground with deep stony cover ensuring underground cavities.

In conclusion, the analysed dataset highlight that also centipedes, in addition to ground beetles (Coleoptera: Carabidae), harvestman (Arachinida: Opiliones) and spiders (Arachnida: Araneae) (Gobbi et al. 2006; Hågvar 2012; Gobbi et al. 2017), are an important component of the ground-dwelling predatory arthropod assemblages living in high-altitude landforms.

Acknowledgements We are grateful to the several students that helped us in collecting centipedes on the Alps; we are also thankful to the following Parks: Parco Nazionale dello Stelvio, Parco delle Orobie Bergamasche, Parco Naturale Adamello Brenta and Parco delle Dolomiti d'Ampezzo, that allowed the permission to collect centipedes.

Appendix 1

List of the species sampled in each sampling point of the Central-Eastern Italian Alps

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Parks	Area	Altitude (m asl)	Habitat type	Sampling technique	Days of traps activity	Sampling year	*Eupolybothrus tridentinus*	*Eupolybothrus longicoirnis*	*Lithobius agilis*	*Lithobius castaneus*	*Lithobius lucifugus*	*Lithobius sp. gr. mutabilis/latro*	*Lithobius pelliccensis*	*Lithobius tricuspis*	*Strigamia transsilvanica*	*Lithobius dentatus*	*Lithobius nodulipes*
PDA	Ghiacciaio Sorapiss Occ. (BL)	2413	DG	Pitfall trapping	75	2017					0.40						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2288	F1	Pitfall trapping	75	2017					0.37						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2282	F1	Pitfall trapping	75	2017					0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2289	F1	Pitfall trapping	75	2017					0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2293	F1	Pitfall trapping	75	2017					0.67						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2285	F1	Pitfall trapping	75	2017	0.13		0.13		0.40						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2282	F1	Pitfall trapping	75	2017			0.13		0.17						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2278	F1	Pitfall trapping	75	2017					0.80						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2276	F1	Pitfall trapping	75	2017					0.93						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2270	F1	Pitfall trapping	75	2017					0.53						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2265	F1	Pitfall trapping	75	2017					0.27						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2217	F1	Pitfall trapping	75	2017			0.27		0.40						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2212	F1	Pitfall trapping	75	2017	0.13		0.53		0.93						

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Parks	Area	Altitude (m asl)	Habitat type	Sampling technique	Days of traps activity	Sampling year	*Eupolybothrus tridentinus*	*Eupolybothrus longicoirnis*	*Lithobius agilis*	*Lithobius castaneus*	*Lithobius lucifugus*	*Lithobius sp. gr. mutabilis/latro*	*Lithobius pelliccensis*	*Lithobius tricuspis*	*Strigamia transsilvanica*	*Lithobius dentatus*	*Lithobius nodulipes*
PDA	Ghiacciaio Sorapiss Occ. (BL)	2226	F1	Pitfall trapping	75	2017					0.27						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2230	F1	Pitfall trapping	75	2017					0.53						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2226	F1	Pitfall trapping	75	2017			0.40		0.40						0.17
PDA	Ghiacciaio Sorapiss Occ. (BL)	2231	F1	Pitfall trapping	75	2017			0.40		0.16						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2170	F1	Pitfall trapping	75	2017			0.13		0.23						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2172	F1	Pitfall trapping	75	2017			0.13		0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2175	F1	Pitfall trapping	75	2017					0.80						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2164	F1	Pitfall trapping	75	2017	0.27		0.13		0.53						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2167	F1	Pitfall trapping	75	2017					0.27						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2169	F1	Pitfall trapping	75	2017	0.13		0.27		0.40						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2126	F1	Pitfall trapping	75	2017					0.80						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2124	F1	Pitfall trapping	75	2017					0.53						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2125	F1	Pitfall trapping	75	2017					0.13						

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Parks	Area	Altitude (m asl)	Habitat type	Sampling technique	Days of traps activity	Sampling year	*Eupolybothrus tridentinus*	*Eupolybothrus longicoirnis*	*Lithobius agilis*	*Lithobius castaneus*	*Lithobius lucifugus*	*Lithobius sp. gr. mutabilis/latro*	*Lithobius pelliccensis*	*Lithobius tricuspis*	*Strigamia transsilvanica*	*Lithobius dentatus*	*Lithobius noduliipes*
PDA	Ghiacciaio Sorapiss Occ. (BL)	1925	F2	Pitfall trapping	75	2017					0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	1929	F2	Pitfall trapping	75	2017			0.13							0.17	
PDA	Ghiacciaio Sorapiss Occ. (BL)	1928	F2	Pitfall trapping	75	2017					0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	1930	F2	Pitfall trapping	75	2017		0.13	0.40		0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	1930	F2	Pitfall trapping	75	2017			0.13		0.27					0.83	0.50
PDA	Ghiacciaio Sorapiss Occ. (BL)	2212	DG	Pitfall trapping	75	2017					0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2211	DG	Pitfall trapping	75	2017					0.27						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2213	DG	Pitfall trapping	75	2017					0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2170	F1	Pitfall trapping	75	2017					0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2196	F1	Pitfall trapping	75	2017			0.13								
PDA	Ghiacciaio Sorapiss Occ. (BL)	2178	F1	Pitfall trapping	75	2017					0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2126	F1	Pitfall trapping	75	2017	0.13		0.27		0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2110	F1	Pitfall trapping	75	2017			0.13		0.27						

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Parks	Area	Altitude (m asl)	Habitat type	Sampling technique	Days of traps activity	Sampling year	*Eupolybothrus tridentinus*	*Eupolybothrus longicoirnis*	*Lithobius agilis*	*Lithobius castaneus*	*Lithobius lucifugus*	*Lithobius sp. gr. mutabilis/latro*	*Lithobius pelliccensis*	*Lithobius tricuspis*	*Strigamia transsilvanica*	*Lithobius dentatus*	*Lithobius nodulipes*
PDA	Ghiacciaio Sorapiss Occ. (BL)	2110	F1	Pitfall trapping	75	2017			0.13		0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2105	F1	Pitfall trapping	75	2017	0.13										
PDA	Ghiacciaio Sorapiss Occ. (BL)	2071	F2	Pitfall trapping	75	2017	0.13		0.67		0.67						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2070	F2	Pitfall trapping	75	2017			0.12		0.27						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2063	F2	Pitfall trapping	75	2017	0.13		0.40		0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2063	F2	Pitfall trapping	75	2017			0.27		0.80						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2035	F2	Pitfall trapping	75	2017			0.40		0.40						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2037	F2	Pitfall trapping	75	2017			0.67		0.13						
PDA	Ghiacciaio Sorapiss Occ. (BL)	2032	F2	Pitfall trapping	75	2017			0.80		0.27						
PNAB	Val d'Amola (TN)	2475	F1	Pitfall trapping	60	2012					0.33						
PNAB	Ghiacciaio d'Agola (TN)	2603	DG	Pitfall trapping	45	2018					0.44						
PNAB	Ghiacciaio d'Agola (TN)	2602	DG	Pitfall trapping	45	2018					0.22						
PNAB	Ghiacciaio d'Agola (TN)	2597	DG	Pitfall trapping	45	2018					0.22						

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Parks	Area	Altitude (m asl)	Habitat type	Sampling technique	Days of traps activity	Sampling year	*Eupolybothrus tridentinus*	*Eupolybothrus longicoirnis*	*Lithobius agilis*	*Lithobius castaneus*	*Lithobius lucifugus*	*Lithobius sp. gr. mutabilis/latro*	*Lithobius pellicensis*	*Lithobius tricuspis*	*Strigamia transsilvanica*	*Lithobius dentatus*	*Lithobius nodulipes*
PNAB	Ghiacciaio d'Agola (TN)	2602	DG	Pitfall trapping	45	2018					0.22						
PNAB	Ghiacciaio d'Agola (TN)	2600	F1	Pitfall trapping	45	2018					0.47						
PNAB	Ghiacciaio d'Agola (TN)	2603	F1	Pitfall trapping	45	2018					0.89						
PNAB	Ghiacciaio d'Agola (TN)	2604	F1	Pitfall trapping	45	2018					0.44						
PNAB	Ghiacciaio d'Agola (TN)	2610	F1	Pitfall trapping	45	2018					0.16						
PNAB	Ghiacciaio d'Agola (TN)	2603	F1	Pitfall trapping	45	2018					0.11						
PNAB	Ghiacciaio d'Agola (TN)	2605	F1	Pitfall trapping	45	2018					0.67						
PNAB	Ghiacciaio d'Agola (TN)	2594	F1	Pitfall trapping	45	2018					0.22						
PNAB	Ghiacciaio d'Agola (TN)	2598	F1	Pitfall trapping	45	2018					0.89						
PNAB	Ghiacciaio d'Agola (TN)	2594	F1	Pitfall trapping	45	2018					0.11						
PNAB	Ghiacciaio d'Agola (TN)	2600	F1	Pitfall trapping	45	2018					0.20						
PNAB	Ghiacciaio d'Agola (TN)	2580	F1	Pitfall trapping	45	2018					0.11						
PNAB	Ghiacciaio d'Agola (TN)	2592	F1	Pitfall trapping	45	2018					0.44						

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Parks	Area	Altitude (m asl)	Habitat type	Sampling technique	Days of traps activity	Sampling year	*Eupolybothrus tridentinus*	*Eupolybothrus longicoirnis*	*Lithobius agilis*	*Lithobius castaneus*	*Lithobius lucifugus*	*Lithobius sp. gr. mutabilis/latro*	*Lithobius pellicensis*	*Lithobius tricuspis*	*Strigamia transsilvanica*	*Lithobius dentatus*	*Lithobius nodulipes*
PNAB	Ghiacciaio d'Agola (TN)	2563	F1	Pitfall trapping	45	2018					0.24						
PNAB	Ghiacciaio d'Agola (TN)	2542	F1	Pitfall trapping	45	2018					0.18						
PNAB	Ghiacciaio d'Agola (TN)	2547	F1	Pitfall trapping	45	2018					0.27						
PNAB	Ghiacciaio d'Agola (TN)	2550	F1	Pitfall trapping	45	2018					0.38						
PNAB	Ghiacciaio d'Agola (TN)	2548	F1	Pitfall trapping	45	2018					0.18						
PNAB	Ghiacciaio d'Agola (TN)	2547	F1	Pitfall trapping	45	2018					0.67						
PNAB	Ghiacciaio d'Agola (TN)	2535	F1	Pitfall trapping	45	2018					0.11						
PNAB	Ghiacciaio d'Agola (TN)	2528	F1	Pitfall trapping	45	2018					0.44						
PNAB	Ghiacciaio d'Agola (TN)	2524	F1	Pitfall trapping	45	2018					0.18						
PNAB	Ghiacciaio d'Agola (TN)	2527	F1	Pitfall trapping	45	2018					0.29						
PNAB	Ghiacciaio d'Agola (TN)	2525	F1	Pitfall trapping	45	2018					0.22						
PNAB	Ghiacciaio d'Agola (TN)	2524	F2	Pitfall trapping	45	2018					0.44						
PNAB	Ghiacciaio d'Agola (TN)	2491	F2	Pitfall trapping	45	2018					0.13						

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Parks	Area	Altitude (m asl)	Habitat type	Sampling technique	Days of traps activity	Sampling year	*Eupolybothrus tridentinus*	*Eupolybothrus longicoirnis*	*Lithobius agilis*	*Lithobius castaneus*	*Lithobius lucifugus*	*Lithobius sp. gr. mutabilis/latro*	*Lithobius pellicensis*	*Lithobius tricuspis*	*Strigamia transsilvanica*	*Lithobius dentatus*	*Lithobius nodulipes*
PNAB	Ghiacciaio d'Agola (TN)	2485	F2	Pitfall trapping	45	2018					0.22						
PNAB	Ghiacciaio d'Agola (TN)	2487	F2	Pitfall trapping	45	2018					0.89						
PNAB	Ghiacciaio d'Agola (TN)	2500	F2	Pitfall trapping	45	2018					0.44						
PNAB	Ghiacciaio d'Agola (TN)	2496	F2	Pitfall trapping	45	2018					0.44						
PNAB	Ghiacciaio d'Agola (TN)	2516	F2	Pitfall trapping	45	2018					0.22						
PNAB	Ghiacciaio d'Agola (TN)	2516	F2	Pitfall trapping	45	2018					0.44						
PNAB	Ghiacciaio d'Agola (TN)	2512	F2	Pitfall trapping	45	2018					0.22			0.44			
PNAB	Ghiacciaio d'Agola (TN)	2509	F2	Pitfall trapping	45	2018								0.11			
PNAB	Ghiacciaio d'Agola (TN)	2507	F2	Pitfall trapping	45	2018					0.11			0.44			
PNS	Valle dei Forni (SO)	2650	F1	Hand searching	–	2004					3						
PNS	Val d'Ultimo (BZ)	2495	RG_A	Pitfall trapping	60	2013–2014					0.17						
PNS	Valle del Braulio (SO)	2485	VS	Pitfall trapping	60	2013–2014					0.15						
PNS	Valle del Braulio (SO)	2485	VS	Pitfall trapping	60	2013–2014					0.12			0.33			
PNS	Val d'Ultimo (BZ)	2450	RG_A	Pitfall trapping	60	2013–2014					0.17			0.17			

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Parks	Area	Altitude (m asl)	Habitat type	Sampling technique	Days of traps activity	Sampling year	*Eupolybothrus tridentinus*	*Eupolybothrus longicoirnis*	*Lithobius agilis*	*Lithobius castaneus*	*Lithobius lucifugus*	*Lithobius sp. gr. mutabilis/latro*	*Lithobius pellicensis*	*Lithobius tricuspis*	*Strigamia transsilvanica*	*Lithobius dentatus*	*Lithobius nodulipes*
PNS	Val d'Ultimo (BZ)	2445	RG_A	Pitfall trapping	60	2013–2014								0.17			
PNS	Val d'Ultimo (BZ)	2424	RG_R	Pitfall trapping	60	2013–2014						0.17					
PNS	Val d'Ultimo (BZ)	2420	RG_A	Pitfall trapping	60	2013–2014					0.67	0.67					
PNS	Val d'Ultimo (BZ)	2419	RG_A	Pitfall trapping	60	2013–2014						0.33					
PNS	Valle dei Forni (SO)	2300	F1	Hand searching	–	2004					2						
PNS	Valle dei Forni (SO)	2245	VS	Hand searching	–	2004	4				4						
POB	Monte Costone (BG)	2610	NEV	Hand searching	–	2016					2						
POB	Val Morta (BG)	2600	F1	Hand searching	–	2015					3						
POB	Val Morta (BG)	2600	F1	Hand searching	–	2015					2						
POB	Val Morta (BG)	2574	RG_A	Pitfall trapping	60	2015					0.17						
POB	Val Morta (BG)	2574	RG_A	Pitfall trapping	60	2015					0.67						
POB	Val Morta (BG)	2574	RG_A	Pitfall trapping	60	2015					0.50						
POB	Lago della Malgina (BG)	2520	F1	Hand searching	–	2016					2						
POB	Vallone Pizzo Recastello (BG)	2400	NEV	Hand searching	–	2016					3				1		
POB	Valle del Trobio (BG)	2370	F1	Pitfall trapping	75	2013–2014					0.13						
POB	Valle del Trobio (BG)	2370	F1	Hand searching	–	2013–2014					3						
POB	Pizzo Coca (BG)	2365	VS	Pitfall trapping	60	2015					0.17			0.50			
POB	Pizzo Coca (BG)	2360	VS	Pitfall trapping	60	2015					0.83						

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Parks	Area	Altitude (m asl)	Habitat type	Sampling technique	Days of traps activity	Sampling year	*Eupolybothrus tridentinus*	*Eupolybothrus longicoirnis*	*Lithobius agilis*	*Lithobius castaneus*	*Lithobius lucifugus*	*Lithobius sp. gr. mutabilis/latro*	*Lithobius pellicensis*	*Lithobius tricuspis*	*Strigamia transsilvanica*	*Lithobius dentatus*	*Lithobius nodulipes*
POB	Valle del Trobio (BG)	2360	VS	Pitfall trapping	75	2013–2014					0.40						
POB	Valle del Trobio (BG)	2360	VS	Hand searching	–	2013–2014					8						
POB	Valle del Trobio (BG)	2360	VS	Pitfall trapping	75	2013–2014					0.40						
POB	Valle del Trobio (BG)	2360	VS	Pitfall trapping	75	2013–2014					0.13						
POB	Pizzo Coca (BG)	2355	GG	Pitfall trapping	75	2015					0.13						
POB	Pizzo Coca (BG)	2345	F1	Pitfall trapping	60	2015					0.17						
POB	Pizzo Coca (BG)	2341	F1	Pitfall trapping	60	2015					0.67						
POB	Pizzo Coca (BG)	2341	VS	Pitfall trapping	60	2015					0.33						
POB	Pizzo Coca (BG)	2337	F1	Pitfall trapping	60	2015					0.67						
POB	Pizzo Coca (BG)	2336	F1	Pitfall trapping	60	2015					0.17						
POB	Pizzo Coca (BG)	2335	VS	Pitfall trapping	60	2015	0.17				0.67						
POB	Pizzo Coca (BG)	2325	VS	Pitfall trapping	60	2015					0.50						
POB	Pizzo Coca (BG)	2301	GG	Pitfall trapping	60	2015					0.17						
POB	Pizzo Tre Signori (BG)	2300	GG	Hand searching	–	2015	1										
POB	Pizzo Coca (BG)	2297	GG	Pitfall trapping	60	2015	0.17							0.17			
POB	Pizzo Coca (BG)	2297	GG	Pitfall trapping	60	2015								0.17			
POB	Pizzo Coca (BG)	2281	GG	Pitfall trapping	60	2015					0.17						
POB	Pizzo Tre Signori (SO)	2270	GG	Hand searching	–	2015					1						

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Parks	Area	Altitude (m asl)	Habitat type	Sampling technique	Days of traps activity	Sampling year	*Eupolybothrus tridentinus*	*Eupolybothrus longicoirnis*	*Lithobius agilis*	*Lithobius castaneus*	*Lithobius lucifugus*	*Lithobius sp. gr. mutabilis/latro*	*Lithobius pellicensis*	*Lithobius tricuspis*	*Strigamia transsilvanica*	*Lithobius dentatus*	*Lithobius nodulipes*
POB	Pizzo Tre Signori (BG)	2265	GG	Hand searching	–	2015	1										
POB	Pizzo Tre Signori (SO)	2250	GG	Hand searching	–	2015					1						
POB	Pizzo Tre Signori (BG)	2170	GG	Pitfall trapping	60	2015											
POB	Pizzo Tre Signori (BG)	2150	GG	Pitfall trapping	60	2015											
POB	Passo del Porcile (BG)	2150	GG	Hand searching	–	2015					3						
POB	Pizzo Tre Signori (BG)	2135	GG	Pitfall trapping	60	2015					0.17						
POB	Pizzo Tre Signori (BG)	2125	GG	Pitfall trapping	60	2015					0.17						
POB	Pizzo Tre Signori (BG)	2120	GG	Pitfall trapping	60	2015					0.17						
POB	Pizzo Camino (BG)	2055	GG	Pitfall trapping	60	2016							0.17	0.50			
POB	Pizzo Camino (BG)	2050	GG	Hand searching	–	2016	1				1		1		1		
POB	Pizzo Camino (BG)	1990	RG_R	Pitfall trapping	60	2016								0.33			
POB	Pizzo Camino (BG)	1985	RG_R	Pitfall trapping	60	2016	0.17	0.5									
POB	Pizzo Camino (BG)	1980	RG_R	Pitfall trapping	60	2016				0.33			0.17				

Park code: Parco Dolomiti d'Ampezzo (PDA), Parco Naturale Adamello Brenta (PNAB), Parco Nazionale dello Stelvio (PNS) and Parco Orobie Bergamasche (POB); Habitat type: RG_A = active rock glacier, RG_R = relict rock glacier, DG = debris-covered glacier, F1 = glacier foreland/iceless moraine (less than 100 years old), F2 = glacier foreland/iceless moraine (more than 100 years old), VS = stable slope, GG = screes lopes. The abundance of individuals is expressed in number of individuals when collected by hand searching and in activity density when sampled by pitfall traps.

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